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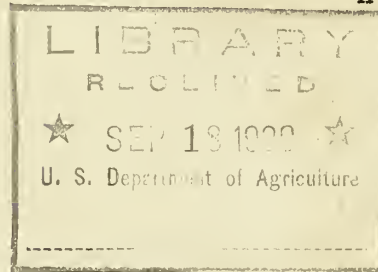
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INVESTIGATIONS ON THE PRECOOLING AND TRANSPORTATION  
OF FLORIDA CITRUS FRUITS - 1939

By

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of Fruit and Vegetable Crops and Diseases.

E/S+J  
(for 2d see no. 49)

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Investigations on the Precooling and Transportation  
of Florida Citrus Fruits - May and June 1939

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By Earl D. Mallison, Associate Horticulturist

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In accordance with the memorandum of understanding entered into between the Bureau of Plant Industry and the Florida Citrus Commission in April 1939, a series of tests was conducted through the remainder of the shipping season to obtain information on:

- (1) The relative effectiveness of different methods of precooling and different lengths of precooling on the transit temperature of the fruit and its market condition.
- (2) The relative desirability of the different methods of shipping citrus fruit as commonly employed by the industry.
- (3) New methods of shipping which might offer promise of increased efficiency or economy.

Through the generous and whole-hearted cooperation of shippers and transportation agencies it was possible to make a number of precooling tests and a total of 8 shipping tests with 17 cars in which a continuous record of transit temperatures was obtained by use of recording thermometers. In addition, similar records were obtained in one boat shipment from Jacksonville to New York City. One shipment of 5 cars was also accompanied from Lakeland to New York by official observers who secured more complete temperature data en route than could be obtained by recording thermometers. They also obtained information on rate of ice meltage and other pertinent data.



In the precooling tests the rate of cooling was determined in the regular precooling rooms for different lengths of time and similar records were obtained when the precooling was done in the cars by use of platform precooling units. Fruit precooled by the different methods was likewise included in the shipping tests so that the influence of precooling as well as of transit refrigeration or ventilation on market conditions could be studied.

As a rule, the plan followed in the shipping tests was to include in each shipment boxes of "test fruit" as nearly alike as possible. Further information concerning these boxes is given in a later paragraph. Two recording thermometers were buried in these test boxes and one was kept with them while the fruit was held for observation after arrival at market destination. This was usually for a period of one week after unloading. Thus, it was hoped that the comparative effects of transit conditions could be noted. However, in considering the results it should be borne in mind that too much weight cannot be given to comparisons of single boxes out of a carload. It would have been better to have had more fruit for the purpose, and it would also have been desirable if test fruit could have been loaded at other places in the cars besides at the top doorway position, which, because of its accessibility, and for reasons of economy, was the only one used in these tests. The results given herein are for the special test lots and apply only generally to the remainder of the consignment. The general condition of each consignment on arrival and the returns received upon sale, while influenced by the grade and size of the fruit, as well as by its original condition, doubtless also reflected the effects of transit conditions. Presumably each shipper received some such information from the market by which these effects could be

evaluated and therefore can supplement the data herein reported, so far as his own cars are concerned.

Previous studies by the Department on shipments of citrus fruit from California to eastern markets have shown that placing ice, equal to one-half the bunker capacity, in the upper half bunker gave results comparable to those obtained with the bunkers iced to capacity. These studies have also shown that placing ice in the upper half bunker gave lower temperatures in transit than did placing the same amount of ice in the lower half.

It seemed desirable to determine the effect of upper half bunker icing under Florida conditions since this method might result in a saving to both shippers and carriers, especially on shipments moved under Item 295.

The experimental work was arranged and conducted by the Bureau in cooperation with various citrus shippers in Florida and the Fruit Growers Express Company. The transportation test was routed via the Atlantic Coast Line, Richmond, Fredericksburg & Potomac RR and Pennsylvania RR.

In the 8 shipping tests and one transportation test made, various methods of refrigeration and ventilation were compared separately and in combination, as follows: (1) vents closed to destination and (2) vents opened at Savannah; (3) initial ice and vents closed to destination; (4) initial ice and vents opened at Waycross; (5) initial ice and vents opened at Potomac Yards. The following variations in refrigeration were tested: (1) bunkers iced to capacity, (2) 4,000 pounds of ice in the upper half, (3) 4,000 pounds of ice in the lower half, (4) 4,800 pounds of ice in the upper half, (5) 4,800 pounds of ice in the lower half, and (6) 8,000 pounds of ice as furnished free under Item 295.

Information was obtained as to temperatures in transit of thoroughly precooled, partially precooled, and nonprecooled shipments moved under the above services.

Records were also obtained as to the loss in weight during transit under the various methods of shipping. The rate of temperature drop during precooling of fruit packed in standard and Bruce boxes, both in cold rooms and in loaded refrigerator cars, cooled with portable platform precooling units was also determined.

#### Methods

Thermometers: In the shipping tests (those unaccompanied by observers) Ryan thermographs were used to obtain the temperatures in transit. The instruments were buried in the fruit at the center of the box near the end. As a precaution against possible instrument failure two instruments were placed in each test box, each instrument replacing two fruits (size 176).

In the transportation test (which was accompanied by observers) electric resistance thermometers were used to determine the temperature of the fruit and of the air in various parts of the load. These instruments are read with an indicator box and are so constructed and placed that temperatures can be obtained at a number of places within the car without opening the doors.

Test fruit: The test fruit was size 176 and was obtained from one grower's lot for each test. When cars were shipped from different packing houses one box of the commercial lot was replaced with the test box, which was placed in the top layer at the doorway, centerline position in each test car. These boxes were removed from the test car and inspected at



time of unloading and subsequently after holding for 5 to 7 days at about 70° F. This holding period approximated the length of time that the fruit would be held on the market before reaching the consumer. Previous experience has shown that on arrival at destination there is often little noticeable difference between comparable lots of test fruit shipped under different methods, but that after this fruit is held for a few days differences begin to appear.

The test boxes containing the thermographs were weighed before loading into the car and were reweighed at time of unloading.

Definition of terms: A number of the terms used in a technical sense in this report are specifically defined below. A "layer" is a course or stratum of the load, parallel to the floor and one package in height. A "stack" is a pile of packages extending from one side of the car to the other, parallel to the ends of the car and one package in length. A "row" is a pile of packages lengthwise of the car parallel to the sides and one package in width. The "bunker position" is a stack next to either bunker bulkhead, the "quarterlength position" is a stack midway between the doors and either bunker, while the "doorway position" is a stack between the doors. The "centerline" is a position in a row midway between the sides of the car.

The "bunker" or "tank" is a compartment at each end of the car where the ice is placed. In the cars shipped under "upper half bunkering" the ice grates are moved from their normal positions at the bottom of the bunker to a location midway between top and bottom, so that the ice is held in the upper half of the bunker.

Under "Item 295" the railroad carrier furnishes without charge varying amounts of ice in the bunkers of cars billed to certain eastern seaboard cities. At the time of these tests 8,000 pounds of ice was thus provided.

"Withering" is the first stage of aging. There is no discoloration of the skin but there are fine wrinkles and reticulations around the button that indicate loss of moisture. The affected skin is slightly soft and flabby. A fruit was listed as withered only if the wrinkling was extensive enough to be noted by the buyer. These distinctions were finely drawn and their practical value therefore should not be overestimated.

"Pitting" was recorded only when 5 or more oil vesicles were involved. It was termed slight or bad on the basis of whether an area of less than or more than 5/16-inch in diameter was involved. Pits involving less than that area are generally overlooked by the trade.

Shipping Tests

Florida 1939-1

Plymouth to Chicago, Ill.  
May 9-14

Car A - Vents closed to destination.

Car B - Vents closed to Savannah, standard ventilation beyond.

This test was made with oranges packed in Bruce boxes. These were loaded 7 rows wide, 4 layers high, and 15 stacks long. The fruit was pre-cooled in cold rooms prior to loading; the loading temperature of fruit in Car A ranged from 45° to 50° F., whereas in car B it was about 45°.

Temperatures in transit: The temperature records obtained with thermographs buried in the center of a box of oranges loaded at the top layer doorway position are reproduced in figure 1. In car A (vents closed to destination) there was only a gradual rise in temperature from 50° to 60° while in car B the temperatures rose rather rapidly from about 42° to 60° as a result of opening the vents at Savannah. The slight fluctuations noted thereafter were caused by changes in outside temperatures, especially the higher temperatures that prevailed during the day.

Inspection at Chicago: One box of fruit from each car was removed for inspection at time of unloading and was reinspected after being held one week at 62-67° F.

Car A - May 14. Fruit temperatures at time of unloading: top doorway 58°, bottom doorway 54°. The test box contained 250 fruits of which 3 were soft, 4 shrivelled, and 5 decayed (Penicillium).

May 21. Inspection showed 7 soft, 8 shrivelled, and 12 decayed (Penicillium) fruits. Approximately 80 percent of the fruit was in a satisfactory condition for juicing. The flavor was good.



ROOM PRECOOLED



FIG. 1



Car B - May 14. Fruit temperatures at time of unloading were, top doorway 57° F., bottom doorway 55°. The test box contained 200 fruits of which 1 was soft, 2 shrivelled, and 1 decayed (Penicillium).

May 21. Three soft, 6 shrivelled, and 7 decayed (Penicillium) fruits. Approximately 90 percent was in fine condition and with excellent flavor.

Remarks: These cars were already loaded when the thermographs were placed in the test boxes. The fruit in car A was "No. 2, Russett" grade, whereas that in car B was "Combination" grade. These differences should be kept in mind when considering the inspection reports from Chicago.

Although the results of this test give no clear indication of the relative effects of the two methods of ventilation in transit on the carrying quality of the fruit, they are of value in showing the temperatures obtained under these conditions. The temperatures during the transit period were slightly lower in car A (vents closed to destination) than in car B (vents opened at Savannah) despite the fact that at time of loading fruit temperatures were generally 5° lower in the latter case.

Florida 1939-2

Fuller's Siding, Winter Haven, Haines City, Florence Villa,  
and Lake Wales to New York  
May 17-24

Car C - Nonprecooled. Item 295 (8,000 pounds ice); vents closed to  
Waycross, standard ventilation beyond.

Car D - Nonprecooled. Item 295 (8,000 pounds ice); vents closed to  
Waycross, standard ventilation beyond.

This test was made in duplicate with oranges packed in Bruce boxes  
at Fuller's Siding. Both cars were loaded 7 rows wide, 4 layers high and  
15 stacks long. The temperature of the fruit at time of loading ranged  
between 80° and 85° F.

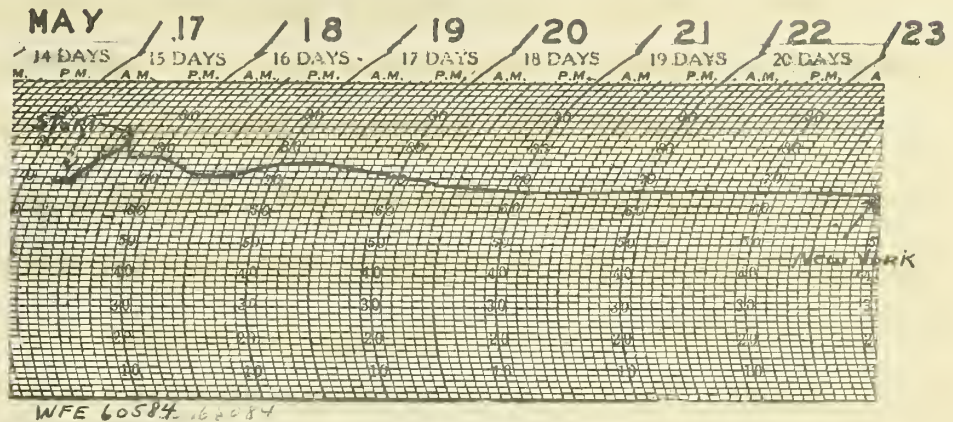
Temperatures in transit: The temperature records obtained with  
thermographs buried in the center of a box of oranges loaded at the top  
layer doorway position are reproduced in figure 2. Since both cars were  
handled in the same manner the temperatures during the transit period were  
about the same. Temperatures dropped during the first few hours to about  
70°, but rose slightly when the vents were opened. This rise was  
followed by a slight drop to a fairly constant temperature of 66° to 68°F.

Inspection at New York: The box of fruit containing the thermograph  
was removed for inspection at time of unloading and was reinspected after  
being held at room temperatures ranging between 69° and 78°, and averaging  
73° F.

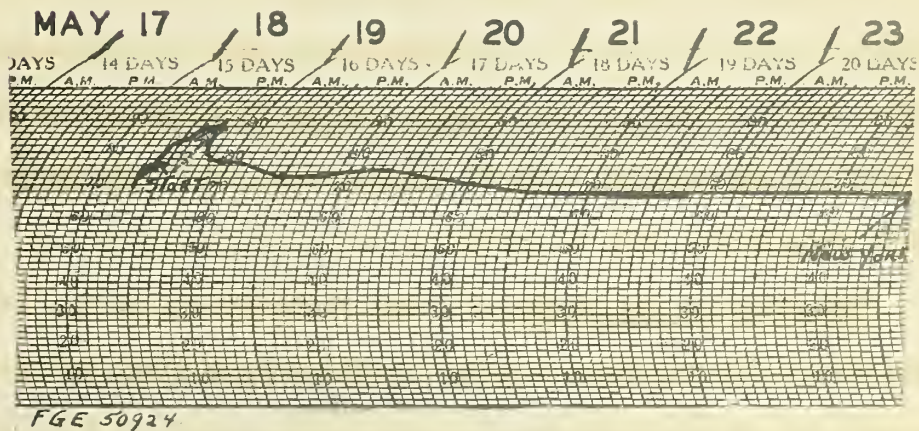
Car C - May 23. The test box contained 176 oranges, of which 3 showed  
bad pitting, 4 withered on stem end, 5 decay (2 Penicillium; 3 stem-end rot).

# TEMPERATURES IN TRANSIT FULLER'S SIDING TO NEW YORK

NON-PRECOOLED



CAR C - VENTS CLOSED TO WAYCROSS,  
OPEN BEYOND. ITEM 295.



CAR D - VENTS CLOSED TO WAYCROSS,  
OPEN BEYOND. ITEM 295.

FIG. 2



May 30. Two pitting, 6 slight aging, 14 withered at stem, 46 decay (2 *Penicillium*; 44 stem-end rot). A total of 51 decayed fruits were found in this box. Stem buttons dry and darkened.

Car D - May 23. This test box contained 176 oranges of which 2 showed slight pitting, 5 withering on stem end, 1 decay (stem-end rot).

May 30. Four pitting, 9 slight aging, 20 withered at stem, 54 decay (1 *Penicillium*, 53 stem-end rot). A total of 55 decayed fruits obtained from this box. Stem buttons mostly dry and darkened.

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Car E - Precooled in car 5 hours. Item 295 (8,000 pounds ice), vents closed to destination.

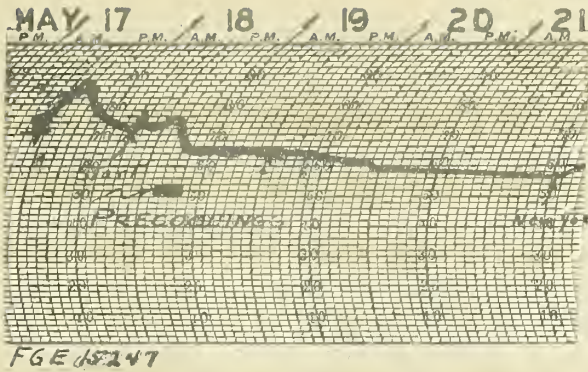
Car F - Precooled in car 4 hours. Item 295 (8,000 pounds ice), vents closed to Potomac Yards, standard ventilation thereafter.

This test was made with fruit packed in Bruce boxes at Winter Haven. Car E was loaded 7 rows wide, 4 layers high, and 15 stacks long (7 stacks oranges, 8 grapefruit). Car F--all oranges from Haines City--was loaded 8 rows wide, 4 layers high, and 15 stacks long. Fruit temperatures at time of loading ranged from 80° to 88° F.

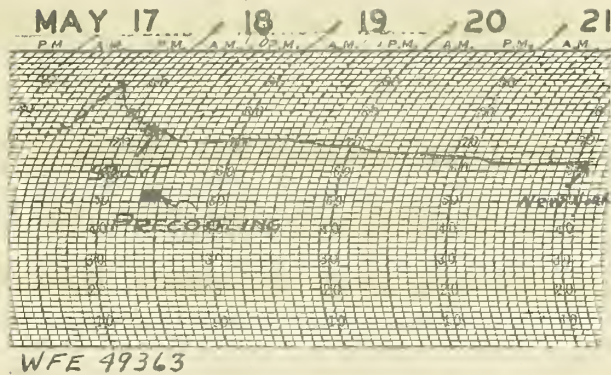
Temperatures in transit: Fruit temperatures in the test box (see figure 3) at the top layer doorway position were about 65° in car E (precooled 5 hours) and about 70° in car F (precooled 4 hours) at the end of the precooling period. During the transit period these temperatures dropped to 56° in car E and to 62° in car F. These records indicate that no further cooling was accomplished by opening the vents at Potomac Yards and, as a matter of fact, that opening the vents there had little or no influence on the subsequent temperatures, since the difference in temperature remained about the same throughout the trip.



PRECOOLED IN CAR -

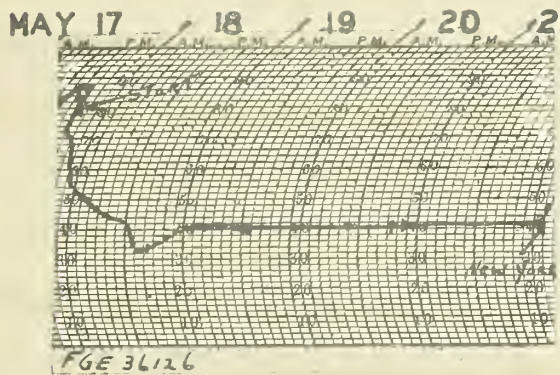


CAR E -  
5 HOURS. WINTER-  
HAVEN. ITEM 295,  
VENTS CLOSED  
TO NEW YORK.

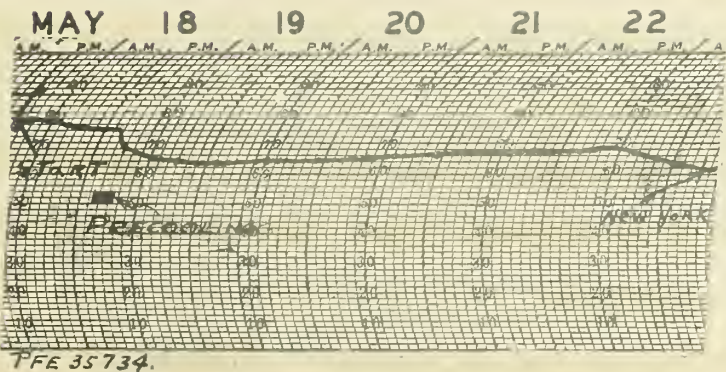


CAR F -  
4 HOURS. HAINES  
CITY. ITEM 295,  
VENTS CLOSED TO  
POTOMAC YARDS,  
OPEN BEYOND.

PRECOOLED IN ROOM -



CAR G -  
OVERNIGHT. FLOR-  
ENCE VILLA. ITEM  
295, VENTS  
CLOSED TO NEW  
YORK.



CAR H -  
4 HOURS. LAKE  
WALES. ITEM 295,  
VENTS CLOSED  
TO NEW YORK.

Inspection at New York:

Car E - May 23. The test box contained 176 oranges of which 4 showed pitting, 7 were withered at the stem end, and 1 was decayed (stem-end rot). There was noticeable withering of the fruit and the stem buttons were dark and dry.

May 30. Inspection showed 4 badly pitted, 7 slight aging, 31 withered at stem end, and 35 decayed (1 Penicillium, 34 stem-end rot). Buttons dark and dry.

Car F - May 22. The test box contained 176 oranges of which 2 showed bad pitting and 1 showed decay (Penicillium). The fruit was in excellent condition and the buttons generally were fresh and green. This car was unloaded 23 hours earlier than car E.

May 29. Inspection showed 5 pitted, 4 slight aging, 23 withered at stem end, and 30 decayed (1 Penicillium, 29 stem-end rot). The fruits that were not shrivelled or decayed, although softer than at time of arrival, were in excellent condition and had a good appearance. Stem buttons were generally dry and dark.

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Car G - Precooled in room overnight. Item 295 (8,000 pounds ice), vents closed to destination.

Car H - Precooled in room 4 hours. Item 295 (8,000 pounds ice), vents closed to destination.

The oranges in car G were packed in Bruce boxes and were precooled to a temperature of 32° to 34° F. at Florence Villa. This car also had 100 boxes of grapefruit and a few tangerines.

The fruit in car H was wrapped and packed in standard boxes at Lake Wales. In the ends of the car the boxes were loaded on their side 4 rows wide

and 3 layers high, while in the center of the car they were loaded on end 6 rows wide, 2 high in 12 stacks, a total of 402 boxes. Fruit temperatures at time of loading generally ranged from 55° to 60° F.

Temperatures in transit:

Car G - The temperatures in the test box (see figure 3) at the top layer doorway rose rather sharply after loading, from 34° to 40° F., and remained at 40° for the remainder of the trip.

Car H - The temperature gradually rose from 63° to 68° during the transit period.

These records indicate that to obtain low temperatures in transit during the warm months of the year the fruit must be thoroughly cooled before loading. Under the conditions of this test the maximum temperature during transit in car G was about 40° as compared with 68° in the less thoroughly precooled car H.

Inspection at New York:

Car G - May 22. The test crate contained 176 oranges, of which 2 were badly pitted. There was no decay or withering of the stem end. The fruit was excellent and the buttons were generally fresh and green.

May 29. Inspection showed 6 pitted oranges, 2 with slight aging, 19 withered at the stem end, 8 decayed (stem-end rot). The few fruits that were slightly withered at the stem end were softer than at time of arrival. The remainder had a good appearance and were in good marketable condition.

Car H - May 23. The test crate contained 176 oranges of which 3 were badly pitted, 5 withered at stem end and 4 decayed (stem-end rot). Buttons were generally dry.

May 30. Inspection showed 5 bad pitting, 7 aging, 20 withered



at stem end and 10 decayed (6 *Penicillium*, 4 stem-end rot). The fruit was less shrivelled than in any of the other cars except car G. The oranges were in good condition, generally bright and fresh, despite the fact that this car had been held in the yards one to two days longer than the other test cars.

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Remarks: It should be remembered that the test fruit used in these six test cars was obtained from one grower's lot and had all received the same treatment until time of precooling and after arrival in New York. Consequently, the differences noted between boxes must have been due largely to differences in treatment during transit.

On arrival, the differences in condition of the test fruit from the different cars was not great nor of commercial significance. However, that from car G (precooled in room overnight) and car F (precooled in car 4 hours) had the best appearance, while that from car C (nonprecooled) and car H (Pre-cooled in room 4 hours) had the most decay. In this connection it should be remembered that cars C and H were unloaded 44 hours after cars F and G.

After the fruit had been held one week at room temperatures ranging from 69° to 78° (average 73° F.) significant differences were noted. The differences in decay and withering at stem are shown in the following table:



Table 1. Percentage of oranges showing withering at stem end and decay after being held one week at room temperature.

Car	Precooling	Fruit temperature <sup>1/</sup>		Withering at stem		Decay	
		Loading	Arrival	Arrival	After 1 week	Arrival	After 1 week
C	None	80-85	67	2.3	8.4	2.8	27.7
D	None	80-85	70	2.8	11.7	0.6	31.6
F	4 hrs.	70	62	0	13.7	0.6	17.8
H	4 hrs.	55-60	64	2.8	12.1	2.3	23.0
E	5 hrs.	65	56	4.0	18.8	0.6	21.2
G	Overnight	32-34	42	0	11.4	0	4.8

<sup>1/</sup> Top doorway - centerline.

From table 1 it is apparent that the lower temperatures obtained with precooling did not noticeably or consistently affect the withering at the stem, nor would this logically be expected since the withering noted was the first stage of aging which normally characterizes the fruit toward the end of the shipping season. There is no evidence that the amount of withering was increased by any drying effect of the forced circulation of the air in precooling.

Table 1 indicates that precooling has a marked influence on the development of decay, not only during transit but during the marketing period as well. The decay was heaviest in the nonprecooled cars and was least in the thoroughly cooled load. A precooling period of 4 to 5 hours which reduced the fruit temperature to a range of 55° to 70° reduced the decay appreciably, but as decay still ranged from 17.8 to 23.0 percent one week after arrival, as compared with only 4.8 percent in the thoroughly precooled fruit, the advantage of thorough precooling is clearly apparent. While the decay found on arrival affects the

wholesale price the fruit will bring and thus is of most immediate concern to the shipper, the rate at which decay develops thereafter must affect the ultimate demand and the favor with which the fruit can be regarded. Retailer and consumer are affected most by the behavior of the fruit in this respect while it is in their hands. From this standpoint adequate precooling wherever facilities are available would seem to be highly desirable as a long range practice for the whole industry.

The decay which developed in these shipments after arrival at destination was largely stem-end rot. Therefore, it would seem that in addition to adequate precooling more emphasis should be placed on proper application of the borax treatment immediately after picking to hold down this decay.

Florida 1939-3

Florence Villa to New York, N.Y.

May 28-31

Car I - Precooled in cold room. Item 295 (8,000 pounds ice), vents closed to destination.

Car J - Precooled in cold room. Item 295 (4,600 pounds ice in upper half of bunker), vents closed to destination.

This test was made with oranges. Car I was loaded with 200 standard boxes and 219 Bruce boxes. The standard boxes were loaded on their sides, 6 rows wide, 4 layers high, with the exception of 4 stacks which were on end 2 layers high. The Bruce boxes were loaded 7 rows wide, 9 stacks long, and 4 layers high. The fruit was precooled to 36° to 40° F.

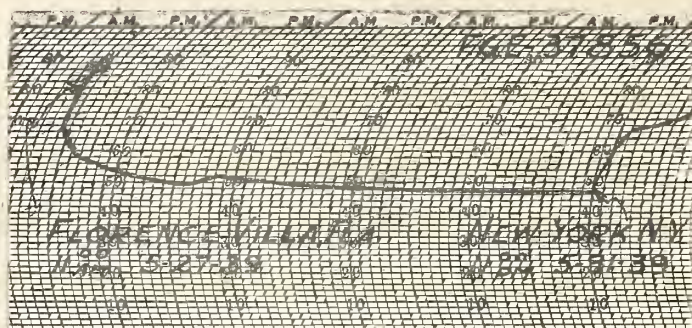
Car J was loaded with 364 Bruce boxes of oranges and 55 standard boxes of grapefruit, the boxes being stowed 7 rows wide, 15 stacks long and 4 layers high. The fruit was precooled to 36° to 38° F.

Temperatures in transit: The temperature records obtained with thermographs buried in the center of a box of oranges loaded at the top layer doorway position are reproduced in figure 4. The temperature records for the two cars shown in this figure are very similar, indicating that the 4600 pounds of ice used in the upper half of the bunker was as effective in maintaining temperatures in transit as 8,000 pounds of ice, as ordinarily used with the ice grates at the bottom of the bunker.

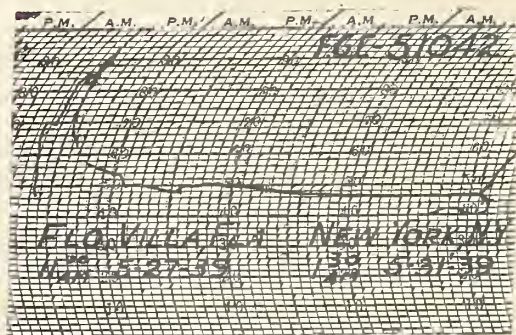
Inspection at New York: The test box containing the thermograph was removed from each car for inspection at time of unloading and was reinspected after being held in the laboratory for one week at 72° to 79° (average 76° F.). The relative humidity varied between 35 and 55 percent, and

# TEMPERATURES IN TRANSIT FLORENCE VILLA, FLA. <sup>TO</sup> NEW YORK, N.Y.

ROOM PRECOOLED



CAR I - ITEM 295 8,000 LBS. ICE.  
VENTS CLOSED



CAR J - ITEM 295 4,800 LBS. ICE IN  
UPPER HALF TANK. VENTS CLOSED.

FIG. 4



averaged about 45 percent.

Car I.- May 31. The test box contained 176 oranges, of which 2 showed severe pitting. The fruit was fresh in appearance, showed no withering, and had green buttons. The only decay was in one fruit (*Penicillium digitatum*) torn by a loose binding wire. The test fruit was in excellent condition, being similar to that shipped in car J.

June 7. Inspection showed 2 slight pitting, 7 bad pitting, 1 slight aging, 8 withered at stem end, 20 decay (1 *Penicillium*, 19 stem-end rot). The fruit was fairly soft and the buttons were somewhat dry.

Car J - May 31. The test box contained 176 oranges of which 3 showed slight pitting and 3 bad pitting, no decay or withering at the stem end, buttons green and fresh.

June 7. Inspection showed 5 slight pitting and 5 bad pitting, 1 slight aging and 16 decay ( 1 *Penicillium*, 15 stem-end rot). Fruit fairly soft and buttons were somewhat dry.

Bunker inspection: The ice remaining in the bunkers shortly after arrival in Jersey City was noted as follows: car I, both bunkers slightly less than half full; car J, about 18 inches in "A" end bunker and about 12 inches in "B" end bunker.

Remarks: The temperatures in transit for cars I and J were about the same; likewise, the test fruit was in about the same condition in both cars. It is doubtful if the differences in pitting, withering and decay are significant. In this test, 4,800 pounds of ice in the upper half bunker was as effective as the 8,000 pounds of ice furnished under Item 295 (close to the bunker capacity of 9,600 pounds) for the satisfactory transportation of oranges.

Florida 1939-4

Winter Garden and Tildenville to Chicago, Ill.  
May 31-June 5

Car K - Precooled in room. 4,000 pounds of ice in bottom half of bunker. Vents closed to destination.

Car L - Precooled in room. 4,000 pounds of ice in upper half of bunker. Vents closed to destination.

Car M - Precooled in car 8 hours. Rule 240, bunkers iced to capacity (9,600 pounds). Vents closed to destination.

Car K was loaded at Winter Garden with 391 standard boxes of oranges and 9 standard boxes of grapefruit. The boxes were loaded on end 6 rows wide, 2 layers high, with a partial third layer next to each bunker. The fruit was precooled to a temperature of 36° to 38° F.

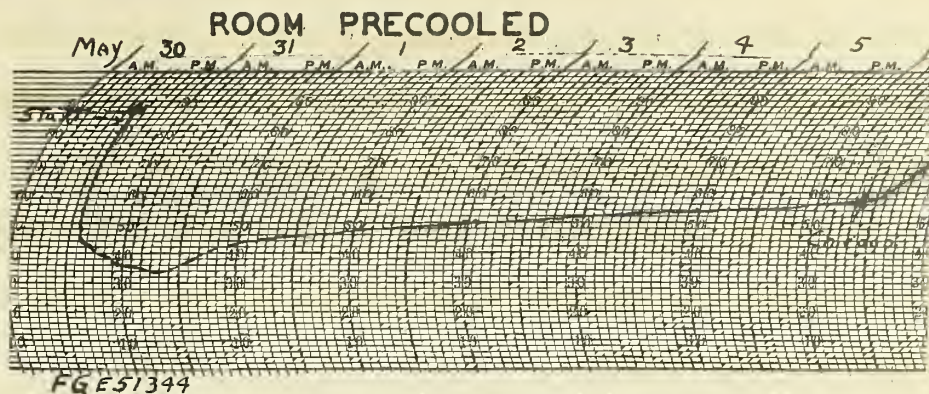
Car L was loaded at Winter Garden with 400 standard boxes, loaded on end 6 rows wide, 2 layers high, with a partial third layer next to each bunker bulkhead. The fruit in this car was precooled to the same temperature (36° to 38° F.) as that in car K.

Car M was loaded at Tildenville with 485 Bruce boxes loaded on their sides 15 stacks long, 7 rows wide and 4 layers high, with 38 boxes forming a partial fifth layer in one end of the car. This load was precooled in the car with a portable platform unit for about 8 hours. At the end of precooling the fruit temperature at the top layer doorway position was about 64° (see Figure 5).

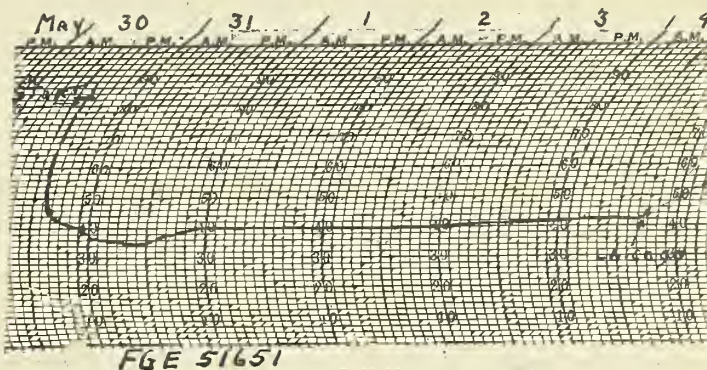
Temperatures in transit: The temperature records obtained with a thermograph buried in the upper half of the standard box loaded in cars K and L, and in the center of the Bruce box loaded in car M, are reproduced in figure 5.



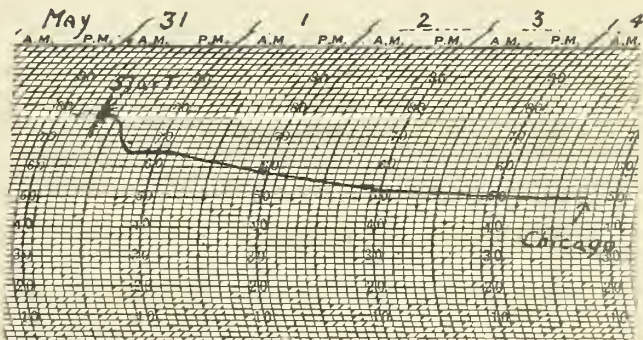
# TEMPERATURES IN TRANSIT WINTER GARDEN TO CHICAGO



CAR K - 4000 POUNDS ICE  
LOWER HALF TANK, VENTS  
CLOSED.



CAR L - 4000 POUNDS ICE  
UPPER HALF TANK, VENTS  
CLOSED.



CAR M - PRECOOLED IN CAR.  
SHIPPED RULE 240, VENTS  
CLOSED.

The fruit in cars K and L had about the same temperature when loaded, but in car K (4,000 pounds ice in lower half of bunker) it rose to about 57° by the time of unloading in Chicago, while in car L (4,000 pounds ice in upper half bunker) it rose only to 40° and remained fairly constant at that temperature for the remainder of the trip.

The fruit temperature in car M (9,600 pounds ice) continued to drop after precooling was stopped and eventually reached a minimum of 50° at the top layer doorway position.

At time of unloading the temperature of the fruit in various parts of these cars was taken with a mercury thermometer. These readings are given in table 2 and show that lower temperatures were obtained in car L (4,000 pounds of ice in the upper half of the bunker) than in either of the others.

Table 2. Fruit temperatures at time of unloading.

Car	Ice	Doorway position		Quarterlength		Bunker position	
		Top °F.	Bottom °F.	Top °F.	Bottom °F.	Top °F.	Bottom °F.
Car K - Lower half		58	53	59	48	58	46
Car L - Upper half		52	48	48	46	56	43
Car M - Full		56	47	58	45	58	48

Note: Car K was unloaded 10:00 a.m., June 5, car L, 4:30 p.m. June 4, and car M, 5:00 p.m. June 4.

Inspection at Chicago: The test box of fruit was removed from each car for inspection at time of unloading and was reinspected after being held 5 days at 65° to 67° F.

Ice in bunkers: Inspection of the bunkers at time of unloading showed that approximately 250 pounds of ice remained in each bunker of car K; 125



to 150 pounds in each bunker of car L; and about 800 pounds in A-end bunker and 1200 pounds in B-end bunker of car M.

Car K - May 5. The test box contained 176 oranges of which 3 showed moderate shrivelling at stem end. There was no decay. The fruit was in good condition and about the same as the test fruit in car M.

May 9. Inspection showed 1 soft, 3 shrivelled and no decay.

Car L - May 4. The test box contained 176 oranges, of which there were 3 with slight stem-end shrivelling. There was no decay. The test fruit was in as good or better condition than that in the other two cars.

May 9. Inspection showed 1 soft, 4 shrivelled, and no decay.

Car M - May 4. The test box contained 176 oranges of which 2 were soft, 2 withered at the stem end, and no decay. The fruit was in good condition.

May 9. Inspection showed 3 soft, 4 withered at the stem end, no decay.

Remarks: Four thousand pounds of ice in the upper half of the bunkers (car L) maintained lower temperatures in transit than did the same amount of ice in the bottom of the bunker (car K). The test fruit in car L (upper half bunker icing) arrived in as good or better condition than did that shipped in car K (lower half bunker icing). This indicates that to obtain best results with 4,000 pounds of ice it should be placed in the upper half of the bunker.

In car M the fruit had the benefit of full bunker initial icing but was not precooled to as low a temperature as that in the other two cars. The transit temperatures were higher in car M than in the other two cars and the condition of the fruit from car M on arrival and after 5 days as well was no better than, if as good as, that in car L, indicating that full

initial icing of cars containing comparatively warm fruit cannot take the place of effective precooling.

The usual procedure in precooling oranges in cold rooms is to circulate the cold air from 7 to 9 hours, which does not include the "soaking" period when the air circulation is stopped. The results of this test indicate that lower temperatures can be obtained with wrapped oranges packed in standard boxes when they are precooled in cold rooms than can be obtained with unwrapped oranges packed in Bruce boxes in about the same length of time when the fruit is precooled in the refrigerator car with a platform unit.

Florida 1939-5

Tildenville to Chicago, Ill.

June 14-18

Car N - Precooled in car. 9,600 pounds of ice, vents closed to destination.

Car O - Precooled in car. 4,800 pounds of ice in upper half bunker, vents closed to destination.

This test was made with oranges packed in Bruce boxes. Each car contained 425 boxes loaded 7 rows wide, 15 stacks long and 4 layers high with 5 boxes forming a partial fifth layer in one end.

The cars were precooled with portable platform precooling units.

Car N was precooled from 4:10 p.m. to 8:20 p.m., June 13 and from 7:00 a.m. to 1:20 p.m., June 14, a total of 10-1/2 hours. Car O was precooled from 3:45 p.m. to 7:45 p.m., June 13, and from 7:00 a.m. to 1:20 p.m., June 14, a total of 10-1/3 hours.

Fruit temperatures in the top of the load at the end of precooling in car N ranged from 48° to 60°, and averaged 55° F., and in car O they ranged from 54° to 61° and averaged 57°.

Temperatures in transit: Unfortunately, the thermographs placed in car N both failed to function. In car O the thermograph buried in the center of a box at the top layer doorway position showed a temperature of 66° F. at the end of the last precooling period, then it dropped slowly to 60° and remained constant at that temperature until near the end of the test, after which it rose to 64°, found upon arrival in Chicago.

Inspection at Chicago: The test box of oranges from each car was removed and inspected at time of unloading and was reinspected after



being held one week at 70° F.

Fruit temperatures in various parts of the load, taken with a mercury thermometer at time of unloading, are given in the following table:

Table 3. Fruit temperatures at time of unloading in Chicago.

Car	Icing	Doorway		Quarterlength		Bunker	
		Top °F	Bottom °F	Top °F	Bottom °F	Top °F	Bottom °F
N	9,600 lbs. ice	56	50	60	46	58	45
O	4,800 " " <u>1</u> /	64	62	67	58	66	57

1/ Ice in upper half of bunker.

Ice in bunkers: At time of unloading the ice remaining in the bunkers was as follows:

Car N - 350 lbs. in each bunker

Car O - None

Car N - June 18. The test box contained 176 oranges of which 6 were unusually soft, 1 was badly shrivelled, and 1 showed decay (Penicillium). The fruit was generally in good condition but showed some shrivelling about the stem end.

June 25. Inspection showed 7 soft oranges, 5 shrivelled, and 3 decayed.

Car O - June 18. The test box contained 176 oranges of which 5 were soft, 2 shrivelled, and 1 decayed. The fruit showed a little more shrivelling than usual and some fruits were getting rather soft.

June 25. Inspection showed 6 soft fruits, 3 badly shrivelled, and 6 decayed (3 Penicillium and 3 stem-end rot).

Remarks: In car O the comparatively high temperatures found at time of unloading, the inferior condition of the test fruit, and the meltage of all the ice prior to arrival of the car at destination indicated that 4,800 pounds of ice, even when placed in the upper half of the bunker, is not sufficient to maintain satisfactory temperatures of inadequately precooled fruit during the hot weather usually experienced in late June. The results in car N in which only about 700 pounds of ice remained of the original 9,600 pounds, indicate that icing to capacity is preferable at this time of the year for shipments of fruit in which the temperature is only lowered to 55° to 60° F. during precooling.

Florida 1939-6

Winter Garden to Chicago, Ill.  
June 15-21

Car P - Precooled in room. 4,000 pounds ice in upper half bunker.

Vents closed to destination.

Car Q - Precooled in room. 4,000 pounds ice in lower half bunker.

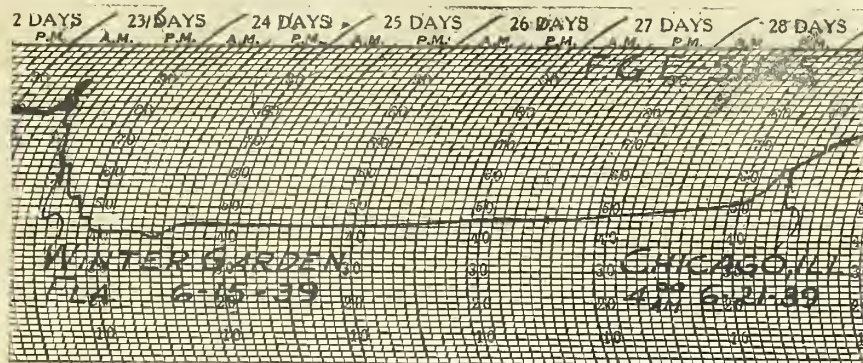
Vents closed to destination.

This test was made with oranges packed in Bruce boxes. Each car contained 420 boxes loaded 4 layers high, 7 rows wide, and 15 stacks long. The test fruit was similar to that in the remainder of the load, which was picked June 12, gassed 61 hours at a temperature of  $85^{\circ}$  -  $90^{\circ}$  with a maintained relative humidity of 96 percent. It was washed, given the "color added" treatment at  $128^{\circ}$ - $130^{\circ}$ , waxed, graded, sized, and packed. The fruit in each car was precooled from 11:00 a.m. to 10:00 p.m., June 15, and from 10:00 a.m. to 11:00 p.m., June 16 - a total of 24 hours. At the end of pre-cooling the temperature of the fruit in car P ranged from  $33^{\circ}$ -  $38^{\circ}$ , average  $35.5^{\circ}$ ; in car Q it ranged from  $33^{\circ}$  to  $42^{\circ}$ , average  $36.5^{\circ}$  F.

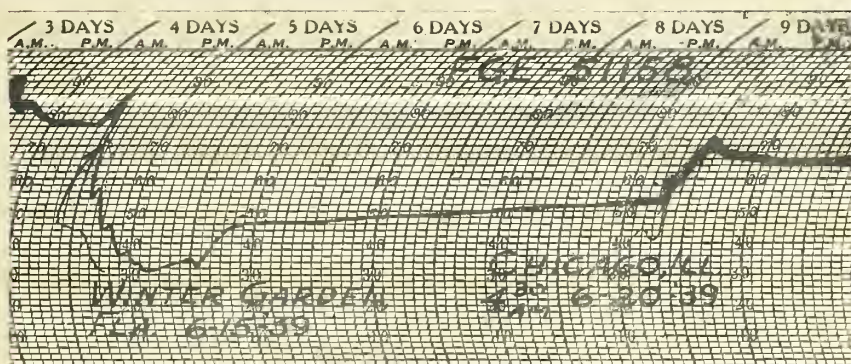
Temperatures in transit: The temperatures obtained with a thermograph buried in the center of a box of oranges are reproduced in figure 6. The irregular drop in temperature during precooling was due to the periodic reversal in direction of the cold air passed through the room. Although the fruit temperatures for the two cars were generally about the same, it is apparent that the test fruit in car P did not cool to as low a temperature as that in car Q. This difference was possibly due to a difference in location of the two boxes in the cold room with respect to the air currents.



# TEMPERATURES IN TRANSIT OF ORANGES SHIPPED BY REFRIGERATOR CAR. WINTER GARDEN, FLA. TO CHICAGO, ILL.



CAR P - 4,000 LBS. ICE. UPPER HALF TANK.



CAR Q - 4,000 LBS. ICE. LOWER HALF TANK.

FIG. 6

Shortly after loading the temperature in car P (upper half bunker icing) (Figure 6) rose from 40° to 44°. This was maintained for about 2-1/2 days, after which it rose to 50° about the time of arrival in Chicago. In car Q (lower half bunker icing) the temperature rose rapidly from 33° to 46° in less than 12 hours and reached 50° in about 2-1/2 days. It was about 52° at time of arrival in Chicago.

Inspection at Chicago: The test box was removed and inspected at time of unloading and was reinspected after being held one week at 70° F.

The temperatures of oranges from boxes transported in various parts of the car are given in the following table:

Table 4. Fruit temperatures at time of arrival in Chicago.

Car	Icing	Doorway		Quarterlength		Bunker	
		Top °F	Bottom °F	Top °F	Bottom °F	Top °F	Bottom °F
P	4,000 lbs. upper half	52	50	52	--1/	50	--1/
Q	4,000 lbs. lower half	54	48	58	46	58	44

1/ Car P unloaded one day later (June 21) so temperatures at these locations could not be obtained.

Ice in bunkers: At time of arrival in Chicago the ice remaining in the bunkers was as follows:

Car P - Practically none.

Car Q - 600-700 pounds in each bunker.

Car P - June 21. The test box contained 176 oranges of which 1 was soft, 1 shrivelled, and none decayed.

June 27. Inspection showed 3 soft fruits, 4 shrivelled and 5 decayed (1 Penicillium and 4 stem-end rot). The fruit held up very well.

Car Q - June 20. This test box likewise contained 176 oranges of which 1 was soft, 1 shrivelled, and none decayed. This fruit was in good condition and held up well in storage.

June 27. Inspection showed 2 soft fruits, 1 shrivelled, and 2 decayed (stem-end rot). This fruit held up very well.

Remarks: Fruit temperatures were consistently lower in the car having the ice in the upper half bunker than in the car in which the same amount of ice was placed in the lower half bunker. It is doubtful whether the small differences in decay found in the test fruit are significant.



Florida 1939-7

Jacksonville to New York, N. Y.  
May 19-24

This test was made with oranges. The two test boxes were carried from Orlando to Jacksonville by automobile on May 19. One box (VII) was placed in the ship-side precooling plant at 10:30 p.m. of the same day, while the companion box (VIII) was kept at room temperature until 8:00 a.m. May 21, when it was placed in the precooler shortly before being loaded into the ship. Box VII was stowed with the regular commercial cargo in the lower hold in the center of hatch No. 2 but Box VIII was placed in the upper 'tween deck in which there were only 4 or 5 other boxes of fruit so that it was exposed to the full sweep of the cold air blast.

Temperatures in transit: The temperature records obtained with thermographs buried in the center of a box of oranges loaded at the top doorway positions in the precooling room are reproduced in figure 7. This figure shows that the temperature dropped rapidly after Box VII was placed in the cold room. Temperatures dropped from 76° to 50° F in about 6 hours, and reached a minimum of 37° just prior to loading on May 21. The temperature rose to about 50° shortly after loading into the ship, after which it gradually dropped to 40° by the time of unloading in New York.

The fruit in Box VIII remained at a high temperature prior to loading in the ship on May 21, after which the temperature dropped from 82° to 60° F during the first 18 hours and reached a minimum of 36° about one day before unloading in New York.

# TEMPERATURES IN TRANSIT OF ORANGES SHIPPED BY BOAT. JACKSONVILLE, FLA. TO NEW YORK, N. Y.

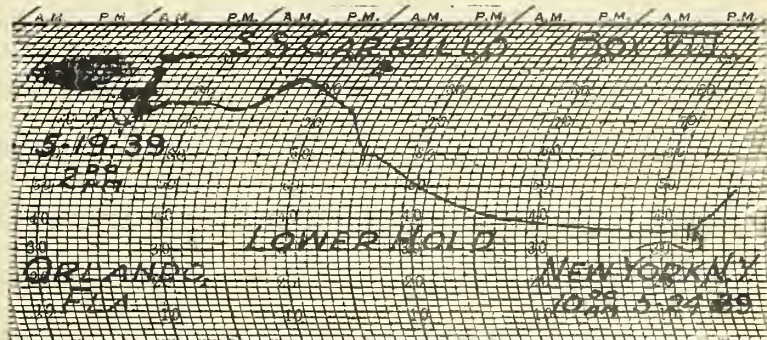
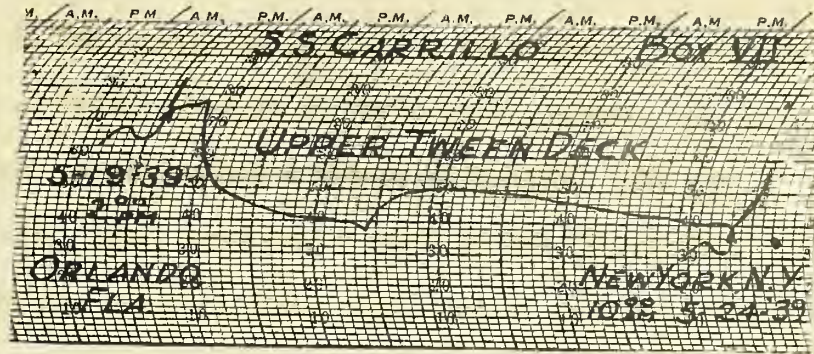


FIG. 7

Inspection at New York: The test boxes were removed for inspection at time of unloading and were reinspected after being held one week at temperatures ranging from 69° to 78°, average 73° F.

Test Box VII (precooled on arrival at Jacksonville) May 24. This box contained 176 oranges, none of which showed withering, pitting or decay.

May 31. Inspection showed 5 badly pitted, 2 aged, 9 withered at stem end, 15 decayed (9 Penicillium, 6 stem-end rot). The fruit in this box was far superior to that in Box VIII (nonprecooled). It was brighter and not so badly wilted, and the stem buttons were fresher.

Test Box VIII. (Nonprecooled) May 24. This box contained 176 oranges of which 3 were badly pitted with no withering or decay.

May 31. Inspection showed 5 badly pitted, 7 aged, 20 withered at the stem end, 10 decayed (6 Penicillium, 4 stem-end rot). The lot was quite definitely of poorer appearance than that in Box VII.

Remarks: The results of this test show the temperatures that were obtained by holding fruit in the ship-side precooling plant about 36 hours prior to loading as compared with fruit passed through the precooler shortly before loading, under which conditions there is practically no precooling. However, the temperatures in transit recorded for Box VIII are not representative of conditions obtained in a fully loaded compartment since this box was carried in a partially loaded compartment and was well exposed to the circulating cold air, so that conclusions cannot be drawn as to the relative carrying quality of well precooled and nonprecooled fruit as normally stowed in full compartments.

(The stowage of the test boxes on board ship was not supervised by a representative of the Department. Through some mischance Box VIII was not stowed in a filled compartment as planned.)



Florida 1939-8

Waverly to Portland, Oregon  
June 7-15

FGE 32954 - Precooled in room. Car preiced with briquets and reiced to capacity by shipper after loading. Vents closed to destination.

This test was made with grapefruit packed in standard boxes, which were loaded on end two layers high, 6 rows wide and 31 stacks long, with a partial third layer of 28 boxes in one end. The car contained ripe fruit of both the Marsh and the Duncan varieties. The fruit was precooled in a cold room to an average of 42.6° F, range 38° to 48°.

Temperatures in transit: The temperatures as obtained with thermographs buried in the upper half of the top layer boxes and in the lower half of the bottom layer boxes, are shown in figure 8. The temperatures at the top layer doorway and quarterlength positions were about the same throughout the transit period. The test fruit, which was precooled to a temperature of 32° F, rose rapidly to the temperature of the rest of the load shortly after it was placed in the car on June 7. At the top layer doorway and quarterlength positions it then rose slowly to 48° and remained fairly constant at that temperature throughout the transit period, but at the bottom layer bunker position it remained between 40° and 44°.

Inspection at Portland: The load had shifted about half the thickness of a grapefruit box, but aside from the lifting of one end of the top of two boxes there was no damage. The center strap held so that no fruit was spilled.

There was 6 to 12 inches of ice remaining on the ice grates of each bunker.



# TEMPERATURES IN TRANSIT OF GRAPEFRUIT SHIPPED BY REFRIGERATOR CAR. WAVERLEY, FLA. TO PORTLAND, ORE.

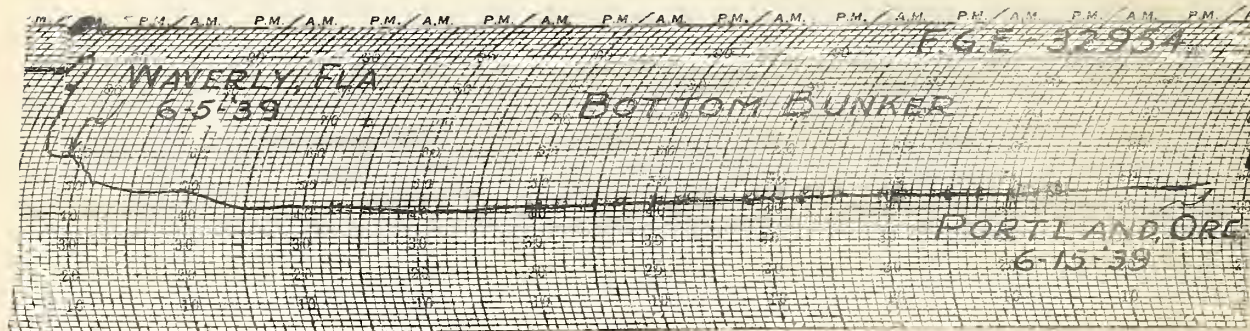
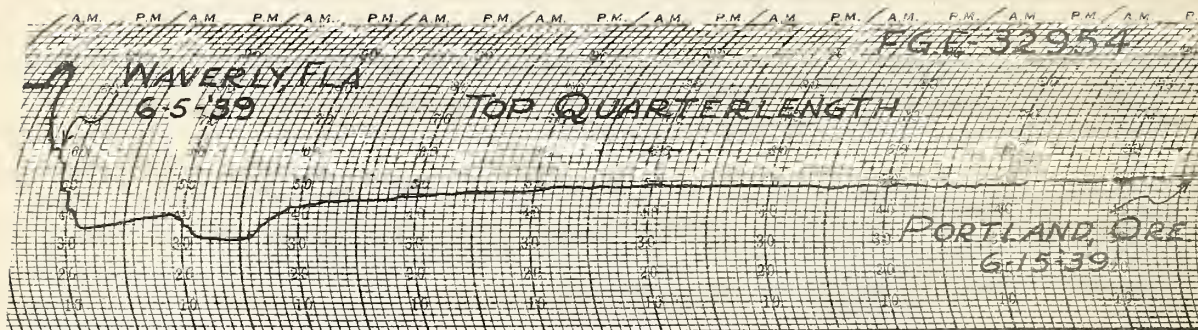
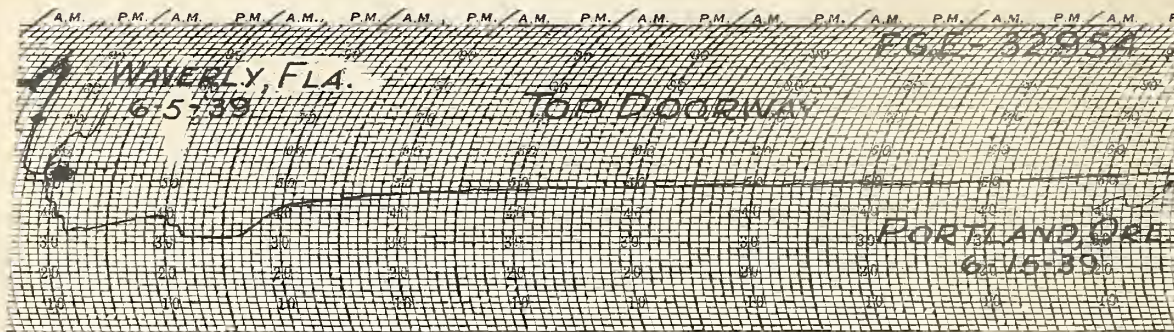


FIG. 8

FLORIDA 1939-8

The outside temperature during unloading was about 68° F., with heavy showers. No sweating of the fruit was observed when the car was unloaded.

A number of boxes from various parts of the load were opened and inspected. No decay was found except for one punctured fruit. The fruit had an attractive outward appearance and while it lacked the firmness expected earlier in the season it was not objectionably soft. Flavor was mild without staleness. So far as was observed there was no watersoaking of the albedo.

Loss in Weight During Transit

The influence of the different shipping methods on changes of weight during transit was studied by weighing the test box in each test car at time of shipment and at time of unloading at destination. The thermographs were included at both weighings so that the total weights found do not represent the actual weight of packed boxes but the changes in weight that occurred during shipment from Florida to New York and Chicago are indicated by the results, shown in table 5.



Table 5. Change in weight of test boxes during transit.

Car	Method of shipping	Desti- nation	Date		Time in cars Days	Weight at		Change lbs.
			Ship- ped	Unload- ed		Fla. lbs.	Desti- nation lbs.	
C	Nonprecooled, Item 295 (8000) <sup>1/</sup>	N.Y.	5/18	5/23	5	106.3	105.2	-1.1
D	Nonprecooled, Item 295 (8000)	N.Y.	5/18	5/23	5	106.5	105.4	-1.1
E	Nonprecooled, Item 295 (8000)	N.Y.	5/18	5/23	5	107.2	105.9	-1.3
F	Precooled, Item 295 (8000)	N.Y.	5/18	5/22	4	105.1	104.5	-0.6
G	Precooled, Item 295 (8000)	N.Y.	5/18	5/22	4	105.9	105.7	-0.2
H	Precooled, Item 295 (8000)	N.Y.	5/18	5/23	5	105.2	104.3	-0.9
I	Precooled, Item 295 (8000)	N.Y.	5/28	5/31	3	103.9	103.8	-0.1
J	Precooled, Item 295 (4800)	N.Y.	5/28	5/31	3	103.5	103.7	+0.2
K	Precooled, Rule 240 (4000)	Chicago	5/31	6/6	6	107.7	107.5	-0.2
L	Precooled, Rule 240 (4000)	Chicago	5/31	6/5	5	106.6	106.0	-0.6
M	Precooled, Rule 240 (9600)	Chicago	5/31	6/5	5	99.5	98.5	-1.0
N	Precooled, Rule 240 (9600)	Chicago	6/14	6/18	4	104.3	102.5	-1.8
O	Precooled, Rule 240 (4800)	Chicago	6/14	6/18	4	104.0	102.5	-1.5
P	Precooled, Rule 240 (4000)	Chicago	6/16	6/21	5	100.0	99.5	-1.5
Q	Precooled, Rule 240 (4000)	Chicago	6/16	6/20	4	98.5	98.3	-0.2
R	Precooled, Item 295 (8000)	N.Y.	6/3	6/7	4	95.9	95.3	-0.6
S	Precooled, Item 295 (4800)	N.Y.	6/3	6/7	4	96.4	95.6	-0.8
T	Precooled, Item 295 (8000)	N.Y.	6/3	6/7	4	95.7	94.1	-1.6
U	Precooled, Item 295 (8000)	N.Y.	6/3	6/7	4	95.0	94.0	-1.0

<sup>1/</sup> Figures enclosed in parenthesis refer to weight of ice placed in car.

No conclusions should be drawn from the above results as to relative loss in weight during shipment under the various conditions represented in these tests. Many more records of this kind should be obtained before attempting to reach such conclusions.



Transportation Test No. 1

Haines City, Florence Villa, and Lucerne Park  
to New York and Baltimore, Md., June 1939

Car R - (FGE 35008). Precooled in room to temperature range of 30° to 44°, average 39° F. Shipped Item 295 (8,000 pounds ice); vents closed to destination.

Car S - (FGE 35623). Precooled in room to temperature range of 36° to 44°, average 40° F. Shipped Item 295, with 4,800 pounds ice in upper half bunker; vents closed to destination.

This portion of the test was made with oranges packed in Bruce boxes at Florence Villa. Each car had 420 boxes loaded 4 layers high, 4 rows wide, and 15 stacks long.

Temperatures in transit: The temperatures obtained with electric resistance thermometers are given in tables 6 and 7 and in figure 9. The thermometer bulb was placed in the orange located in the third row from the sides, top and bottom and end of the crate.

It is apparent from these data that the temperatures at comparable positions in the two cars were fairly close together, the greatest difference being from 2° to 3° F. The bottom layer temperatures were generally lower in car R (8,000 pounds of ice) than in car S, but the top layer temperatures at all positions except the doorway were lower in car S than in car R.

Inspection at New York: The test boxes were removed for inspection at time of unloading and were reinspected after being held for one week at room temperatures ranging between 78° and 85°, average 81° F. Relative humidity varied between 40 and 55 percent, average about 46 percent.

DEGREES F.

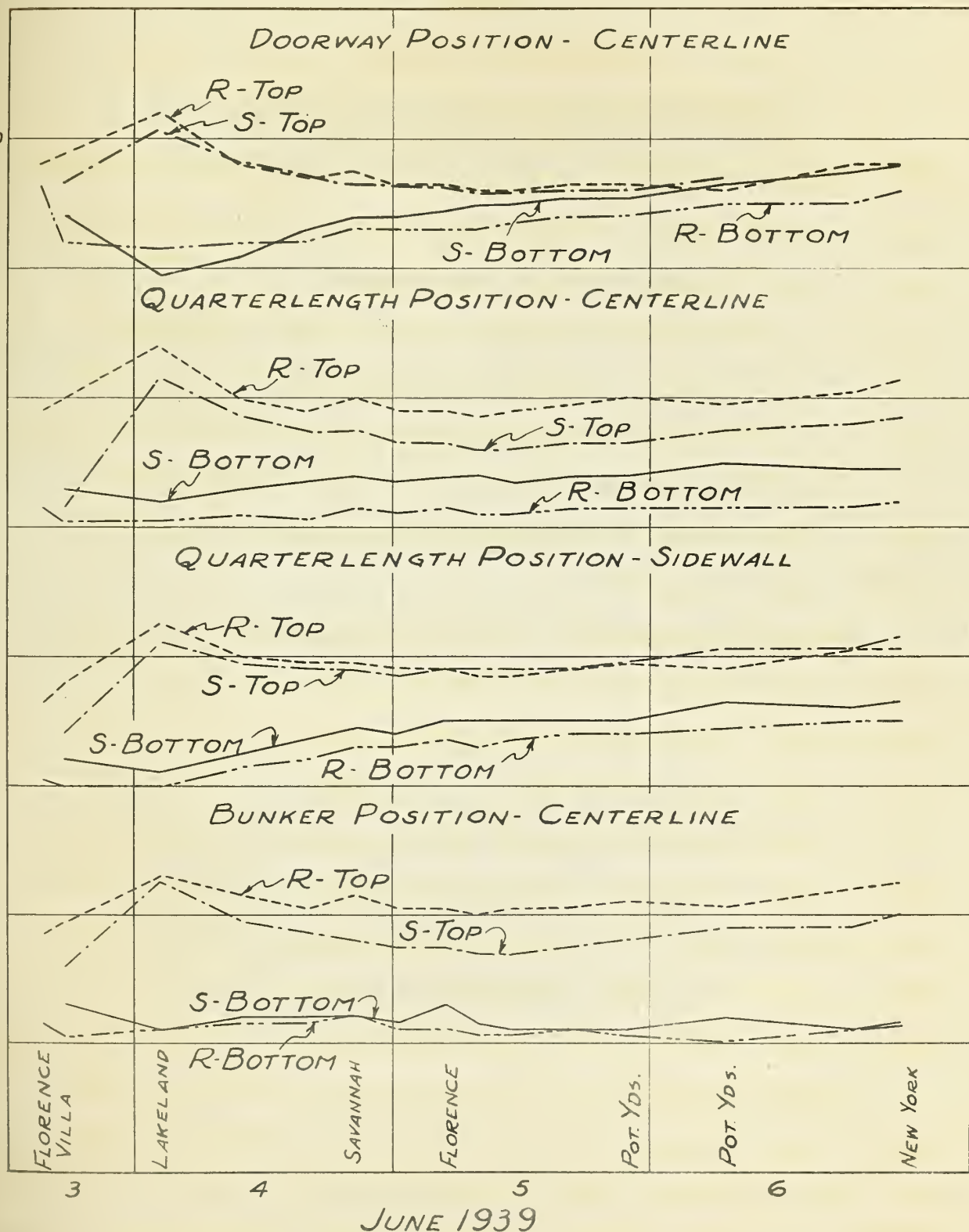


Table 6. Temperatures in transit of oranges loaded in car R (FGE 35008), room-precooled, shipped Item 295 (8000 lbs. ice), vents closed to destination, from Florence Villa to New York, June 1939.

Place	Day of mo.	Time	Out-side temp °F	1	2	3	4	5	6	7	8	9	10	11	12
Florence Villa, Fla.	3	3:30p	90	46.5	48.0	49.0	41.5	40.5	41.5	56.5	48.5	46.5	41.0	82.0	43.0
" " "	3	5:30p	89	42.0	42.0	50.0	40.5	40.0	40.5	51.0	49.5	48.0	40.0	70.5	37.5
Lakeland, Fla.	4	2:30a	72	41.5	52.0	54.0	40.5	40.0	41.0	50.0	53.0	52.5	40.5	65.0	38.5
High Springs, Fla.	4	10:00a	85	42.0	48.0	50.0	41.0	41.5	41.5	35.5	51.5	50.0	41.0	56.0	38.5
Waycross, Ga.	4	4:00p	95	42.0	47.0	49.0	40.5	42.0	41.5	36.5	50.5	49.5	41.0	57.5	39.0
Savannah, Ga.	4	8:30p	73	43.0	47.5	50.0	41.5	43.0	42.0	37.0	51.5	49.5	42.0	58.0	40.0
Charleston, S.C.	5	12:45a	72	43.0	46.5	49.0	41.0	43.0	41.0	36.5	50.5	49.0	41.0	56.0	39.5
Florence, S.C.	5	5:00a	73	43.0	46.5	49.0	41.5	43.5	41.0	36.5	50.5	49.0	41.5	55.0	40.0
Fayetteville, N.C.	5	8:00a	78	43.0	46.0	48.5	41.0	43.0	40.5	36.0	50.0	48.5	41.5	54.0	40.0
So. Rocky Mount, N.C.	5	11:00a	84	43.5	46.0	49.0	41.0	43.5	40.5	37.0	50.5	48.5	41.5	54.5	40.0
Richmond, Va.	5	4:30p	83	44.0	46.5	49.5	41.5	44.0	41.0	38.5	50.5	49.0	42.0	57.0	41.0
Potomac Yards, Va.	5	9:40p	70	44.0	46.5	50.0	41.5	44.0	40.5	38.5	51.0	49.5	42.0	58.0	41.0
" " "	6	7:00a	76	45.0	46.0	49.5	41.5	44.5	40.0	36.0	50.5	49.0	41.5	--	41.5
Jersey City, N.J.	6	7:00p	72	45.0	48.0	50.5	41.5	45.0	41.0	39.0	52.0	50.5	42.0	59.5	42.5
New York, N.Y.	6	11:30p	66	46.0	48.0	51.5	42.0	45.0	41.5	38.5	52.5	50.5	42.5	57.0	42.5

Location of thermometers:

- No. 1 -- Doorway, bottom layer, centerline.
- No. 2 -- Doorway, top layer, centerline.
- No. 3 -- Quarterlength, top layer, centerline.
- No. 4 -- Quarterlength, bottom layer, centerline.
- No. 5 -- Quarterlength, bottom layer, sidewall.
- No. 6 -- Bunker, bottom layer, centerline.
- No. 7 -- Bunker, bottom layer, centerline (air).
- No. 8 -- Bunker, top layer, centerline.
- No. 9 -- Quarterlength, top layer, sidewall.
- No. 10 -- Quarterlength, second layer, centerline.
- No. 11 -- Doorway, top layer, centerline (air).
- No. 12 -- Doorway, second layer, centerline.



Table 7. Temperatures in transit of oranges loaded in car S (FGE 35623), room-precooled, Item 295 (4800 lbs. ice in upper half bunker), vents closed to destination, from Florence Villa to New York, June 1939.

Place	Day of mo.	Time	Out-side temp °F	1	2	3	4	5	6	7	8	9	10	11	12
Florence Villa, Fla.	3	5:25p	89	44.0	46.5	41.5	43.0	42.0	43.0	53.5	46.0	44.0	---	82.5	48.0
Lakeland, Fla.	4	2:30a	72	39.5	50.5	51.5	42.0	41.0	41.0	48.0	52.5	51.0	---	65.0	39.5
High Springs, Fla.	4	10:00a	85	41.0	48.0	48.5	43.0	42.5	42.0	36.0	49.5	49.5	---	53.5	39.5
Waycross, Ga.	4	4:00p	95	43.0	47.0	47.5	43.5	43.5	42.0	36.5	48.5	49.0	---	54.0	40.5
Savannah, Ga.	4	8:30p	73	44.0	46.5	47.5	44.0	44.5	42.0	37.5	48.0	49.0	---	54.5	41.0
Charleston, S.C.	5	12:45a	72	44.0	46.5	46.5	43.5	44.0	41.5	36.5	47.5	48.5	---	52.5	40.5
Florence, S.C.	5	5:00a	73	44.5	46.5	46.5	44.0	45.0	43.0	37.0	47.5	49.0	---	52.0	41.0
Fayetteville, N.C.	5	8:00a	78	45.0	46.0	46.0	44.0	45.0	41.5	37.5	47.0	49.0	---	51.5	41.0
SoRocky Mount, N.C.	5	11:00a	84	45.0	46.0	46.0	43.5	45.0	41.0	37.5	47.0	49.0	---	52.0	41.0
Richmond, Va.	5	4:30p	83	45.5	46.0	46.5	44.0	45.0	41.0	38.0	47.5	49.0	---	54.0	42.0
Potomac Yards, Va.	5	9:40p	70	45.5	46.0	46.5	44.0	45.0	41.0	38.5	48.0	49.5	---	54.0	41.5
" " "	6	7:00a	76	46.5	47.0	47.5	45.0	46.5	42.0	38.5	49.0	50.5	---	51.0	43.5
Jersey City, N.J.	6	7:00p	72	47.5	---	48.0	44.5	46.0	41.0	40.0	49.0	50.5	---	57.0	43.5
New York, N. Y.	6	11:30p	66	48.0	---	48.5	44.5	46.5	41.5	40.5	50.0	51.5	---	55.0	43.5

Location of thermometers:

- No. 1 -- Doorway, bottom layer, centerline.
- No. 2 -- Doorway, top layer, centerline.
- No. 3 -- Quarterlength, top layer, centerline.
- No. 4 -- Quarterlength, bottom layer, centerline.
- No. 5 -- Quarterlength, bottom layer, sidewall.
- No. 6 -- Bunker, bottom layer, centerline.
- No. 7 -- Bunker, bottom layer, centerline (air).
- No. 8 -- Bunker, top layer, centerline.
- No. 9 -- Quarterlength, top layer, sidewall.
- No. 10 -- Quarterlength, second layer, centerline.
- No. 11 -- Doorway, top layer, centerline (air).
- No. 12 -- Doorway, second layer, centerline.

Car R - June 7. The test box contained 176 oranges of which 2 were slightly withered at the stem end, 1 was badly aged, 2 were badly pitted, and 2 were decayed (stem-end rot) following injuries. The fruit was mostly firm and bright, but a number showed slight oil spotting. Stem-buttons were generally fresh and green.

June 14. Inspection showed 14 pitted (4 slight, 10 bad), 9 aged (8 slight, 1 bad), 21 withered at the stem, and 37 decayed (stem-end rot).

Car S - June 7. The test box contained 176 oranges of which 2 were slightly withered at the stem end, 1 slightly aged, 5 pitted (2 slight, 3 bad), and 2 decayed (stem-end rot) following injuries. The fruit was in about the same condition as that from car R.

June 14. Inspection showed 15 pitted (3 slight, 12 bad), 14 aged (9 slight, 5 bad), 22 withered at the stem end, and 47 decayed (stem-end rot).

Bunker inspection: One hatch in each bunker was opened at Waycross, Fayetteville, Potomac Yards and New York (at time of unloading) to determine the amount of ice remaining. This was computed on the basis of the space between the top of the ice and the bottom of the hatch, or where the ice was fairly well melted, by estimating the quantity of ice remaining in the bunkers. However, unless ice is barred down it is impossible to obtain an entirely accurate estimate of the ice remaining and this was not done.

Table 8. Approximate quantity of ice remaining in bunkers of cars R and S.

Car	Lakeland lbs.	Waycross lbs.	Fayetteville lbs.	Potomac Yards lbs.	New York lbs.
R	8,000	6,400	4,500	3,600	2,600
S	4,800	3,300	1,500	700	200

Car T (FGE 34665). Fruit precooled in car 6 hours. Shipped under Item 295 (8000 lbs. ice). Vents closed to Potomac Yards, standard ventilation beyond.

Car U (FGE 33868). Same as car T except fruit precooled in car 4-1/2 hours.

These cars were loaded with oranges packed in Bruce boxes at Haines City. Each car had 420 boxes loaded 7 rows wide, 4 layers high, and 15 stacks long. Fruit temperatures at time of loading ranged from 83° to 85°, average 84°, in car T and from 82° to 84°, average 83° F. in car U.

Temperatures in transit: The temperatures in various parts of the load during transit are given in figure 10 and tables 9 and 10.

The fruit was precooled after loading in the car with the type of precooling units that employ brine from the warehouse refrigerating plant and can be moved along the loading platform from car to car as needed. When this method is used, the cooled air enters the car through a top doorway opening and is forced over and down through the load, returning to the unit at a bottom doorway opening. This reverses the normal air circulation in a refrigerator car in which the cooled air enters the loading space through the bottom bunker bulkhead openings, moves upward through the load, and returns



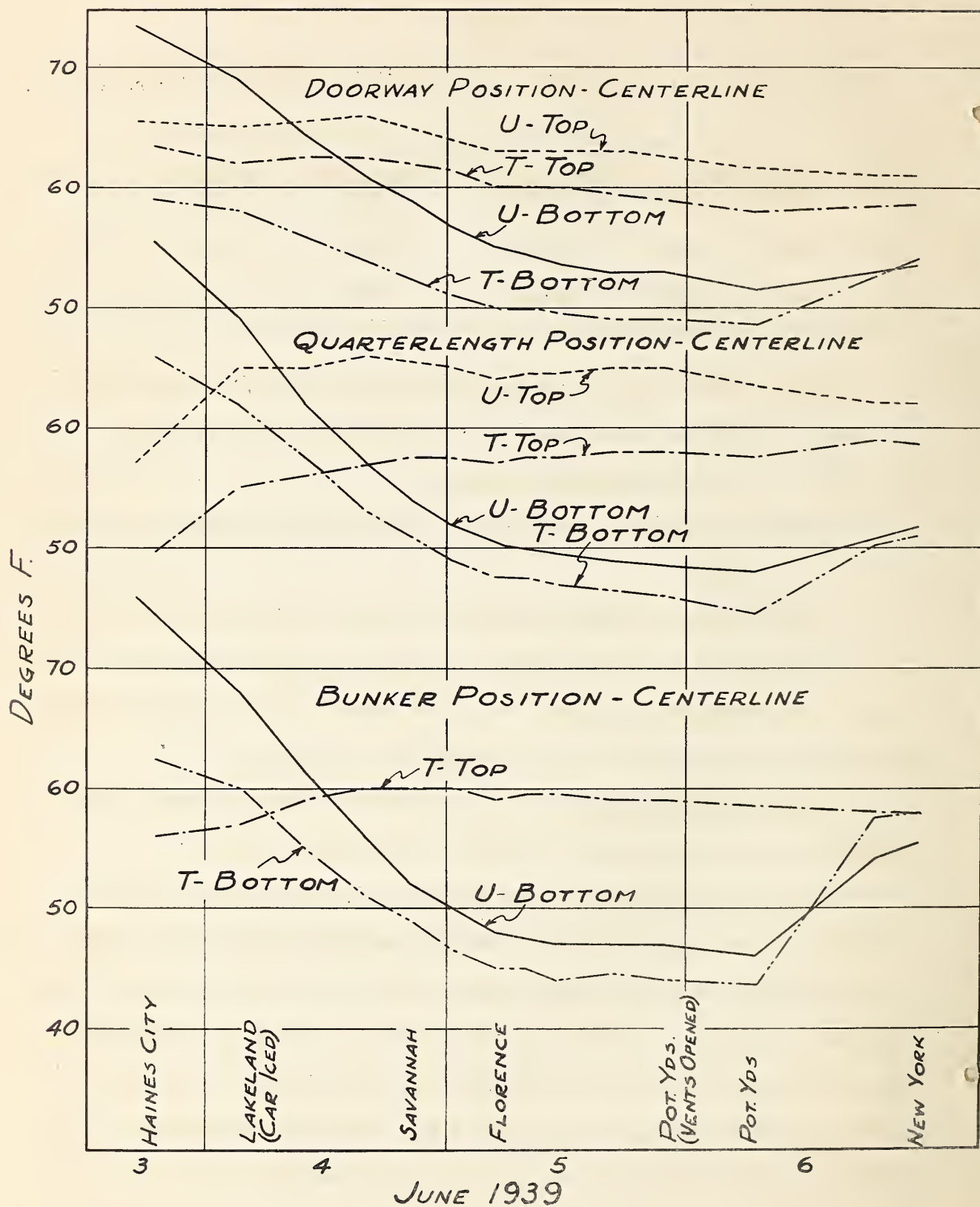


Table 9. Temperatures in transit of oranges loaded in car T (FGE 34665), precooled in car 6 hours, shipped under Item 295 (8000 lbs. ice), vents opened at Potomac Yards, Va., from Haines City to New York, N. Y., June 1939.

Place	Day of mo.	Time	Out-side temp °F	1	2	3	4	5	6	7	8	9	10	11	12
Haines City, Fla.	3	7:00p	84	59.0	63.5	49.5	66.0	73.0	62.5	42.0	56.0	59.5	63.0	38.7	66.0
Lakeland, Fla.	4	3:30a	73	58.0	62.0	55.0	62.0	65.5	60.0	57.5	57.0	60.5	60.0	63.8	62.0
High Springs, Fla.	4	10:00a	85	56.0	62.5	56.0	57.5	60.0	55.0	35.0	59.0	62.5	59.0	61.0	60.0
Waycross, Ga.	4	4:00p	95	54.0	62.5	57.0	53.0	56.0	51.0	35.5	60.0	63.0	57.5	62.5	58.0
Savannah, Ga.	4	8:30p	73	52.5	62.0	57.5	51.0	53.5	49.0	36.0	60.0	63.0	56.0	63.0	57.0
Charleston, S.C.	5	12:45a	72	51.0	61.5	57.5	49.0	51.5	46.5	36.0	60.0	62.5	55.0	62.0	55.5
Florence, S.C.	5	5:00a	73	50.0	60.0	57.0	47.5	49.5	45.0	35.5	59.0	61.5	53.0	61.0	54.0
Fayetteville, N.C.	5	8:00a	78	50.0	60.0	57.5	47.5	49.5	45.0	35.5	59.5	61.5	53.0	61.0	53.5
So. Rocky Mount, N.C.	5	11:00a	84	49.5	60.0	57.5	47.0	49.0	44.0	36.0	59.5	60.5	52.5	61.0	53.0
Richmond, Va.	5	4:30p	83	49.0	59.5	58.0	46.5	48.5	44.5	35.5	59.0	60.5	52.0	62.5	53.0
Potomac Yards, Va.	5	9:40p	70	49.0	59.0	58.0	46.0	48.0	44.0	35.0	59.0	60.0	51.0	63.0	52.5
" " "	6	7:00a	76	48.5	58.0	57.5	45.5	47.0	43.5	39.5	58.5	58.5	50.0	60.0	50.0
Jersey City, N.J.	6	7:00p	72	52.5	58.5	59.0	50.0	51.0	57.5	60.5	58.0	59.0	51.0	67.0	50.5
New York, N. Y.	6	11:30p	66	54.0	58.5	58.5	51.0	52.0	58.0	59.0	57.5	59.0	52.0	63.5	51.0

Location of thermometers:

- No. 1 -- Doorway, bottom layer, centerline.
- No. 2 -- Doorway, top layer, centerline.
- No. 3 -- Quarterlength, top layer, centerline.
- No. 4 -- Quarterlength, bottom layer, centerline.
- No. 5 -- Quarterlength, bottom layer, sidewall.
- No. 6 -- Bunker, bottom layer, centerline.
- No. 7 -- Bunker, bottom layer, centerline (air).
- No. 8 -- Bunker, top layer, centerline.
- No. 9 -- Quarterlength, top layer, sidewall.
- No. 10 -- Quarterlength, second layer, centerline.
- No. 11 -- Doorway, top layer, centerline (air).
- No. 12 -- Doorway, second layer, centerline.

Table 10. Temperatures in transit of oranges loaded in car U (FGE 33868), precooled in car  $4\frac{1}{2}$  hours and shipped under Item 295 (8000 lbs. ice), vents opened at Potomac Yards, from Haines City to New York, June 1939.

Place	Day of mo.	Time	Out-side temp °F	1	2	3	4	5	6	7	8	9	10	11	12
Haines City, Fla.	3	5:00p	90	72.8	65.3	57.0	75.6	81.0	75.8	49.0	--	53.5	--	52.0	72.5
Lakeland, Fla.	4	3:30a	73	69.0	65.0	64.8	69.0	72.0	68.0	67.0	--	64.5	--	70.0	70.5
High Springs, Fla.	4	10:00a	85	64.5	65.5	65.0	62.0	65.5	61.5	36.0	--	66.0	--	66.5	67.5
Waycross, Ga.	4	4:00p	95	61.0	65.8	65.8	57.2	60.0	56.0	37.7	--	66.8	--	68.5	65.0
Savannah, Ga.	4	8:30p	73	59.0	65.0	65.3	54.2	57.0	52.0	38.0	--	66.2	--	69.5	63.0
Charleston, S.C.	5	12:45a	72	56.7	64.0	65.0	52.0	54.2	50.0	37.8	--	65.8	--	68.0	61.5
Florence, S.C.	5	5:00a	73	55.0	63.2	64.2	50.5	52.5	48.0	37.5	--	65.0	--	66.5	59.5
Fayetteville, N.C.	5	8:00a	78	54.3	63.0	64.5	50.0	51.6	47.5	36.8	--	65.0	--	66.5	59.0
So. Rocky Mount, NC.	5	11:00a	84	53.7	62.8	64.5	49.4	51.0	47.0	37.0	--	65.0	--	66.5	58.5
Richmond, Va.	5	4:30p	83	53.0	62.8	65.0	49.0	50.7	47.2	37.2	--	65.0	--	69.0	57.5
Potomac Yards, Va.	5	9:40p	70	53.0	62.3	64.8	48.5	50.0	47.0	37.0	--	64.5	--	69.5	56.5
" " "	6	7:00a	76	51.5	61.5	63.5	48.0	49.0	46.0	--	--	63.0	--	64.5	54.5
Jersey City, N.J.	6	7:00p	72	53.0	61.0	62.0	50.5	55.0	54.0	--	--	63.0	--	68.0	54.5
New York, N.Y.	6	11:30p	66	53.3	61.0	62.0	51.7	56.2	55.6	--	--	62.6	--	65.5	54.5

Location of thermometers:

- No. 1 -- Doorway, bottom layer, centerline.
- No. 2 -- Doorway, top layer, centerline.
- No. 3 -- Quarterlength, top layer, centerline.
- No. 4 -- Quarterlength, bottom layer, centerline.
- No. 5 -- Quarterlength, bottom layer, sidewall.
- No. 6 -- Bunker, bottom layer, centerline.
- No. 7 -- Bunker, bottom layer, centerline (air).
- No. 8 -- Bunker, top layer, centerline.
- No. 9 -- Quarterlength, top layer, sidewall.
- No. 10 -- Quarterlength, second layer, centerline.
- No. 11 -- Doorway, top layer, centerline (air).
- No. 12 -- Doorway, second layer, centerline.



to the bunker through the top bunker opening. In this test the normal air circulation was resumed after the precooling units were disconnected. This can be noted by reference to figure 10, especially for the bottom layer positions. The influence of the reversal of air movement on fruit temperatures is very noticeable, especially on June 4 (see figure 10). During the early part of the transit period the temperatures in the bottom layer, which were but little affected by the precooling, dropped rapidly due to the influence of the ice in the bunkers. Accompanying this was an increase in the top layer temperatures.

In car T the 1-1/2 hours longer precooling period resulted in lower temperatures. However, the differences were rather small, being generally less than 4°, except at the top layer doorway position which was exposed to the full blast of the entering cold air.

In accordance with the billing instructions the vents of these cars were opened shortly after arrival in Potomac Yards. No noticeable temperature change followed while the cars were standing in the yards, but while they were in transit from Alexandria to New York the warmer outside air which was thus permitted to enter the car caused a sharp rise in the temperature of the bottom layer fruit. Apparently, ventilation had no influence on top layer temperatures, probably because of the small difference between the temperature of the top layer fruit and that of the outside air at this time.

Inspection at New York: Car T-- June 7. The test box contained 176 oranges of which 3 were slightly withered, 1 slightly aged, 7 pitted (3 slightly, 4 bad), and 1 decayed (stem-end rot). The test fruit was slightly fresher than that from car U. Many of the stem buttons were

fairly dry and dark.

June 14. Inspection showed 8 pitted (2 slight, 6 bad), 4 aged (3 slight, 1 bad), 27 withered at stem end, and 59 decayed (1 Penicillium, 58 stem-end rot).

Car U - June 7. The test box contained 176 oranges of which 2 were slightly withered, 3 pitted (2 slight, 1 bad) and 2 decayed (stem-end rot following injuries). The sound fruit was not as fresh in appearance as that from cars R and S, the fruit was softer and the stem buttons were drier and darker.

June 14. Inspection showed 8 fruits pitted (3 slight, 5 bad), 5 aged (4 slight, 1 bad), 23 withered at stem end and 46 decayed (2 Penicillium and 44 stem-end rot).

Bunker inspection: The same method of estimating ice meltage was used with these cars as with cars R and S. The approximate quantity of ice remaining in the bunkers at the various inspections is given in the following table:

Table 11. Approximate quantities remaining in bunkers of cars T and U

Car	Lakeland	Waycross	Fayetteville	Potomac Yards	New York
	lbs.	lbs.	lbs.	lbs.	lbs.
T	8000	5400	3600	2100	125
U	8000	6000	3000	1800	100

Car V (FGE 67035). Nonprecooled. Shipped under Item 295 (5000 lbs. of ice). Vents closed to Potomac Yards, standard ventilation beyond.

This test was made with oranges packed in Bruce boxes at Lucerne Park. The car contained 405 boxes of oranges and 17 Bruce boxes of grapefruit loaded 7 rows wide, 4 layers high, and 15 stacks long. Part of the fruit which was packed and kept on the floor overnight had lower temperatures than the fruit packed on the day of loading. This accounted for the wide range in temperatures at time of loading which was from 78° to 95°, average 90° F.

Temperatures in transit: Temperatures in various parts of the load during transit are given in figure 1.1 and in table 1.2. These data show that during transit to Potomac Yards the 8000 pounds of ice dropped the fruit temperature near the center of the crate in the top layer from about 90° to 72°-74° F., and in the bottom layer to 52°-54° F. It will be noted that the temperatures continued to drop during the entire trip but the rate of decrease was very slow toward the end. Under the conditions prevailing ventilation was not required prior to arrival of the car at Potomac Yards and it is probable that no benefit resulted from opening the vents at that point. An increased rate of cooling can be obtained from ventilation only when outside temperatures are lower than those inside the car.

Inspection after arrival: The test box was removed at time of unloading at Baltimore during the early morning of June 6 and taken to Arlington Farm, Va., where it was inspected immediately and again after storage for one week at 70° F.



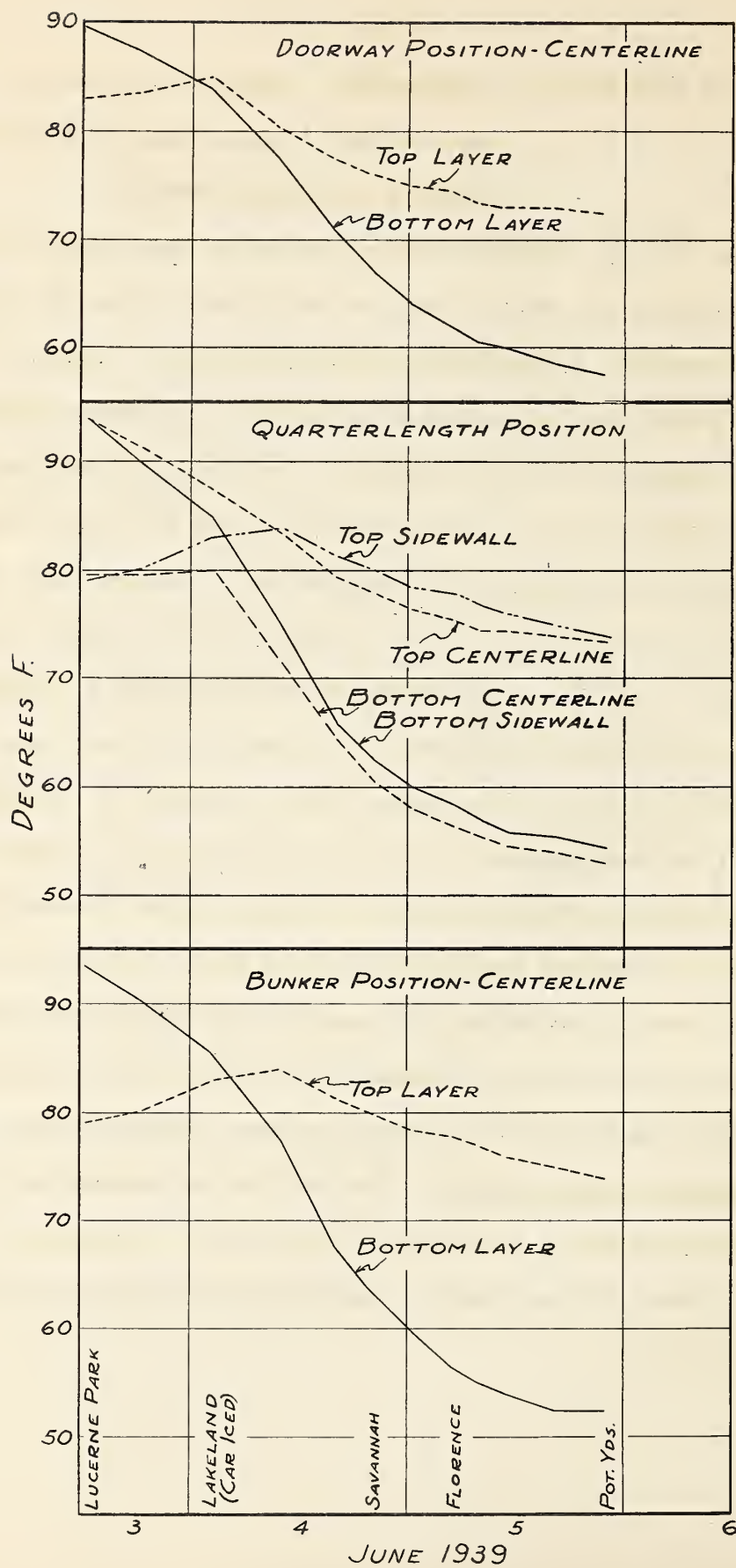


Table 12. Temperatures in transit of oranges loaded in car V  
(FGE 67035), nonprecooled, shipped under Item 295 (8000  
lbs. ice), vents opened at Potomac Yards, from Lucerne  
Park to Baltimore, Md., June 1939.

Place	Day of mo.	Time	Out- side temp °F	1	2	3	4	5	6	7	8	9	10	11	12
Lucerne Park, Fla.	3	12:30p	87	89.5	83.0	94.0	79.5	94.0	93.5	81.5	78.0	79.0	78.0	88.0	90.5
" " "	3	6:15p	93	87.5	83.5	91.5	79.5	90.0	90.5	84.5	80.0	80.0	79.0	93.0	89.5
Lakeland, Fla.	4	2:30a	72	84.0	85.0	87.5	80.0	85.0	85.5	79.0	80.5	83.0	79.5	84.5	82.5
High Springs, Fla.	4	10:00a	85	77.5	80.5	83.5	71.5	75.0	77.5	42.5	80.0	84.0	76.0	81.0	83.0
Waycross, Ga.	4	4:00p	95	71.0	77.5	79.5	64.5	66.0	67.5	42.5	77.5	81.5	72.0	81.0	78.0
Savannah, Ga.	4	8:30p	73	67.0	76.0	78.0	60.5	62.5	64.0	41.5	76.5	80.0	70.0	80.0	75.5
Charleston, S.C.	5	12:45a	72	64.0	75.0	76.5	58.0	60.0	60.0	40.5	75.0	78.5	67.5	77.0	73.0
Florence, S. C.	5	5:00a	73	62.0	74.5	75.5	56.5	58.5	56.5	42.0	75.0	78.0	66.0	76.0	71.0
Fayetteville, N.C.	5	8:00a	78	60.5	73.5	74.5	55.5	57.0	55.0	41.5	74.0	77.0	65.0	75.0	69.5
So. Rocky Mount, NC.	5	11:00a	84	60.0	73.0	74.5	54.5	56.0	54.0	41.5	74.0	76.0	64.0	75.0	68.5
Richmond, Va.	5	4:30p	83	58.5	73.0	74.0	54.0	55.5	52.5	41.5	74.0	75.0	63.0	76.5	66.5
Potomac Yards, Va.	5	9:40p	70	57.5	72.5	73.5	53.0	54.5	52.5	42.0	73.0	74.0	62.0	76.5	65.5

Location of thermometers:

- No. 1 -- Doorway, bottom layer, centerline.
- No. 2 -- Doorway, top layer, centerline.
- No. 3 -- Quarterlength, top layer, centerline.
- No. 4 -- Quarterlength, bottom layer, centerline.
- No. 5 -- Quarterlength, bottom layer, sidewall.
- No. 6 -- Bunker, bottom layer, centerline.
- No. 7 -- Bunker, bottom layer, centerline (air).
- No. 8 -- Bunker, top layer, centerline.
- No. 9 -- Quarterlength, top layer, sidewall.
- No. 10 -- Quarterlength, second layer, centerline.
- No. 11 -- Doorway, top layer, centerline (air).
- No. 12 -- Doorway, second layer, centerline.

Car V - June 6. The test box contained 176 oranges of which 1 was badly wilted, 2 showed slight aging, 23 slight pitting, and 2 were decayed (stem-end rot). The fruit was generally firm and in good condition. The buttons were mostly green.

June 13. Inspection showed 43 withered (33 slight, 10 bad), 18 slightly pitted, and 57 decayed (1 Penicillium, 56 stem-end rot). The fruit was slightly soft to soft and the buttons were mostly brown.

Bunker inspection: The same procedure was used in estimating the amount of ice remaining in the bunker in this car as with the others. The approximate amount of ice remaining at the various stations en route follows: Lakeland, 8000 pounds; Waycross, 3800 pounds; Fayetteville, 1600 pounds; Potomac Yards, 500 pounds; Baltimore, 200 pounds.

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General remarks: The results of this test indicate that the temperatures obtained from the use of 4800 pounds of ice in the upper half bunker were comparable to those obtained from 8000 pounds of ice as ordinarily used, although slightly more decay developed after one week on the market in the one box of test fruit from the car containing ice in the upper half bunker than in that from the car with 8000 pounds of ice.

It is apparent that the use of 8000 pounds of ice with the nonprecooled shipment in car V was effective in causing a continued drop in temperature between Florida shipping point and Potomac Yards where the vents were opened. However, because of the lack of precooling of the fruit and its comparatively high temperatures during transit, heavier decay was found in this shipment than in any of the others after one week's holding on the market.

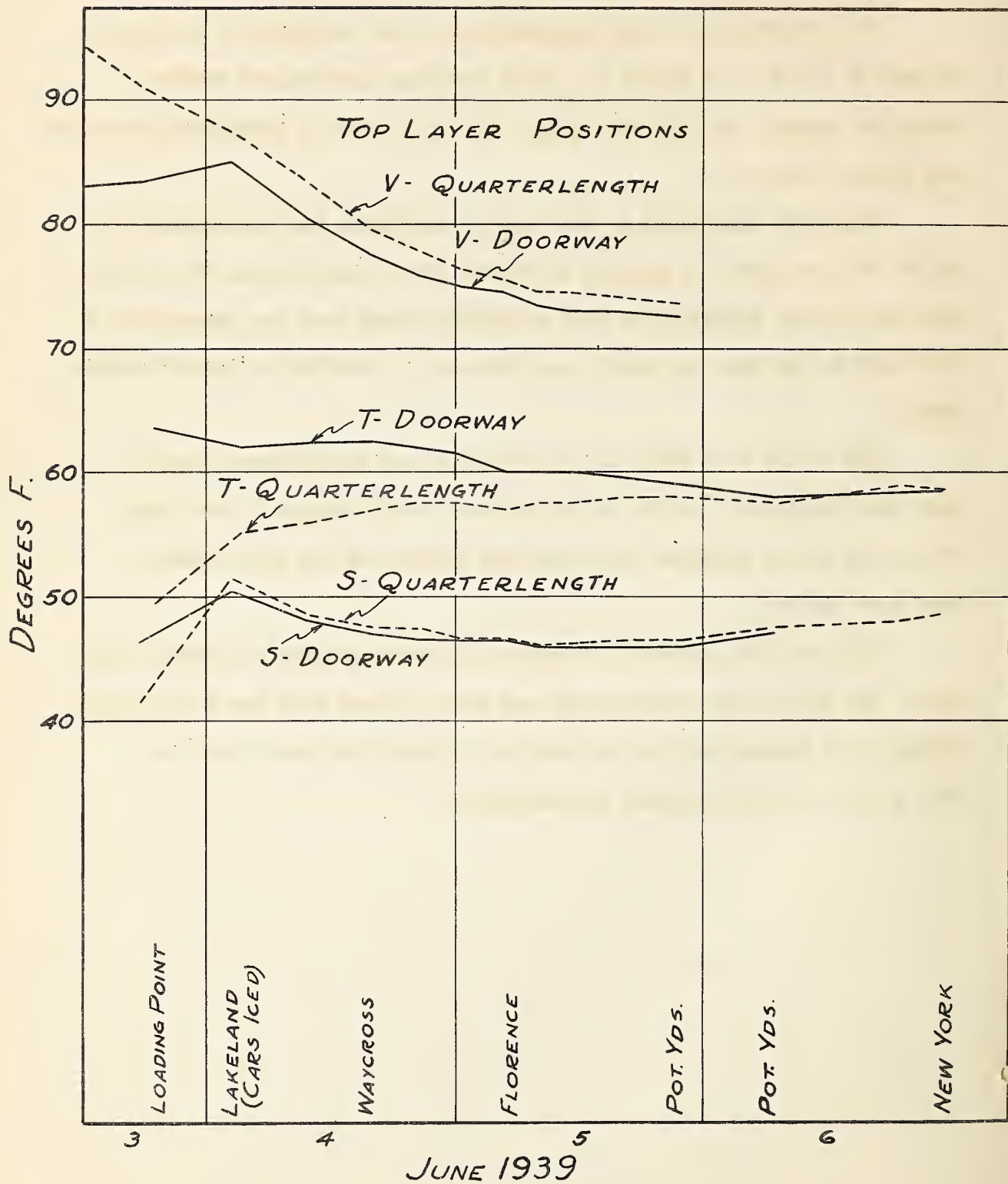


The comparison of fruit temperatures in the top layer of the loads in cars S, T and V, in figure 12, shows that when low transit temperatures are desired, to hold down decay, the fruit must be thoroughly precooled and shipped under ice.

Under the conditions of this test, ventilation was not required in any of the cars prior to arrival at Potomac Yards, and because of the fact that the outside temperatures were generally higher than the temperature of the fruit in the cars no benefit was obtained by ventilation beyond Potomac Yards.

All of the test fruit in the five cars was second-grade, having many skin blemishes. By the end of the one week's storage it was badly wilted and barely salable. The fruit was flabby and the stem-buttons were dark and dry.

The loss from stem-end rot after one week's storage was heavy in all lots. The least decay (22 percent) was found in that from car R (well precooled, 8000 pounds ice) and the heaviest in that from cars T and V-- 34.7 percent and 34.1 percent respectively.



Precooling Test No. 1

Winter Garden, Fla., May 9-10.

Room 5 - Equipped with one baffle curtain located on the south end about one-third the distance toward opposite end of room. Fruit in Bruce boxes.

Room 3 - Equipped with two baffle curtains so that the room was divided into three equal sections. Fruit in Bruce boxes.

These rooms are 12 feet wide, 24 feet long, and 6-1/2 feet high. The ducts opening into the room are in the ceiling and are 10-1/2 inches wide, and 10 feet long, located next to the end walls of the room. The doors opening into the rooms are in the north and south ends, and for the purpose of this report the ends of the room are designated as "north" or "south." The canvas curtain could be dropped from the ceiling to about the top of the second layer box forming a baffle to force the air through the stacked fruit.

Temperatures were obtained with electric resistance thermometers so arranged that readings could be made from outside without opening the doors. Thermometers were located in the top and bottom layers of boxes stowed on their sides along the centerline of the room (midway between the east and west sidewalls) and in the row next to the west sidewall. In the tables these locations are designated as "center" and "side". The Bruce boxes (size 176) were opened and the bulb inserted in an orange in the third row from the outside in one end of the box. Two of these boxes, one near each doorway, had an ad-



ditional thermometer placed in an exposed fruit in the top side. These positions were not in the direct air blast but were near the positions used by the man in charge of precooling operations to obtain fruit temperature records by the use of mercury thermometers.

Precooling log: Rooms partially filled on May 8. Doors in duct openings partially opened during night of May 8-9. Loading completed morning of May 9.

May 9, 1939. 9:45 am.- 11:00 am. Air inlet north duct

11:00 am.- 11:55 am. " " south "

11:55 am.- 1:55 pm. " " north "

1:55 pm.- 2:55 pm. " " south "

2:55 pm.- 3:55 pm. " " north "

Ducts closed at 3:55 pm.

7:00 pm.- Air inlet, north side

8:00 pm.- " " south "

9:00 pm.- Cut off.

Outside temperature 75° - 80° F.

Temperatures during precooling: Fruit temperatures in various parts of the precooling rooms are given in tables 13 to 16, inclusive. These tables are so arranged that a comparison can be made of the average top and bottom temperatures with those obtained at positions near the doors ordinarily used by the refrigerating engineer in obtaining his records. This was done for the purpose of furnishing him with a guide or index as to temperatures existing in other parts of the room

not ordinarily accessible.

A comparison of the fruit temperatures obtained at the "2nd curtain" position in Room No. 3 with the comparable position, "quarter-length", in Room 5 shows that the use of the second curtain gave lower temperatures in this section of the room.

The records indicate that there was an equalization of temperatures during the 10-hour period (9:00 p.m., May 9 to 7:00 a.m., May 10) following precooling. Temperatures at the end of this period ranged from 36° to 48.5°, mostly between 37° and 41° F., in all parts of the room.

Table 13. Temperatures obtained near center of Bruce boxes loaded in top (4th) layer of precooling room (Room No. 5) with one curtain; Winter Garden, Fla., May 9-10, 1939.

Direction of air blast	Length of precooling period	Air		Fruit												Outer 2/			Average	
		Inlet	Outlet	At curtain				Quarter- 1/		North end		South end	North end	Inner	Outer	Inner and outer				
				Center		Side		Center	Side	Center	Side									
				°F	°F	°F	°F										°F	°F	°F	°F
South (	hrs.	°F	°F	62.5	63.0	66.5	---	69.5	66.0	84.5	83.0	65.5	65.5	86.5	70.7	76.0	71.6			
(	0	---	---	58.5	59.5	62.5	---	64.5	56.0	73.0	67.0	53.5	53.5	69.0	63.0	61.2	62.6			
(	1	33.0	45.0	57.0	58.0	59.5	---	62.0	52.0	65.0	59.5	50.0	50.0	62.0	57.0	56.0	56.8			
North (	1-1/2	26.5	43.0	52.5	50.5	51.5	---	61.0	52.5	60.5	59.5	43.0	43.0	58.5	55.4	50.8	54.4			
(	2	27.0	43.5	49.5	44.5	47.0	---	61.5	51.5	60.0	59.0	40.5	40.5	57.0	53.3	48.8	52.3			
South (	3	33.5	39.5	47.5	45.0	45.0	---	60.0	48.0	54.5	51.5	41.0	41.0	50.0	50.2	45.5	49.2			
(	4	26.5	40.0	43.0	40.0	40.0	---	58.5	45.5	49.5	47.5	36.0	36.0	47.5	46.3	41.8	45.3			
North (	5	32.0	36.0	40.5	40.0	37.5	---	56.0	41.0	43.5	41.0	36.5	36.5	41.0	42.8	38.8	41.9			
South (	6	27.0	38.0	37.0	36.5	35.5	---	55.5	40.5	41.0	39.5	31.5	31.5	40.0	40.8	35.8	39.7			
South (	Temp. drop in 6 hrs.		---	25.5	26.5	31.0	---	14.0	25.5	43.5	44.5	34.0	34.0	46.5	30.0	40.2	31.9			
	6 1/2	---	---	37.0	37.0	36.0	---	53.5	42.0	41.0	39.5	38.0	38.0	44.0	40.9	41.0	40.9			
South (	Temp. change during 3-hr. "soaking period"		---	.0	+.5	+.5	---	-2.0	+1.5	.0	.0	+.6.5	+.6.5	44.0	.0	+5.3	+1.2			
	7	30.5	35.5	36.5	37.5	35.0	---	52.5	39.0	37.5	35.0	34.5	34.5	37.5	39.0	36.0	38.3			
North (	8	27.5	35.5	34.5	34.0	33.0	---	52.0	38.0	37.0	35.0	31.0	31.0	37.5	37.5	44.3	35.6			
	Total temp. drop		---	28.0	29.0	33.5	---	17.5	28.0	47.5	48.0	34.5	34.5	49.0	33.1	41.8	35.0			
7:00 a.m.	5/10	---	---	36.5	36.5	36.0	---	48.5	41.0	40.5	40.5	39.0	39.0	43.5	41.4	41.3	41.4			
	4/	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---			

1/ Position similar to that where second curtain was located in Room No. 3 (see tables 15 and 16).

2/ Position in top layer where temperatures are obtained by man in charge of precooling operations not directly under air blast.

3/ Temperatures after 3-hour "soaking period".

4/ Ducts closed at 9:00 p.m., May 9. This reading obtained the next morning at 7:00 a.m.



Table 14. Fruit temperatures obtained near center of Bruce boxes located in bottom layer of precooling room (No. 5) with one curtain. Winter Garden, May 9-10, 1939

Direction of air blast	Length of precooling period	Air		Fruit										Average		
		Inlet	Outlet	South end		At curtain		Quarter-1/ length		North end		Outer 2/		Inner	Outer	Inner and outer
				Center	Side	Center	Side	Center	Side	Center	Side	South end	North end			
	hrs.	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F
South (	0	---	---	69.0	69.5	66.5	64.0	67.0	61.0	85.0	84.0	65.5	86.5	70.7	76.0	71.6
(	1/2	35.0	47.5	67.5	63.0	62.0	56.5	58.5	59.0	81.5	74.5	53.5	69.0	65.3	61.3	64.4
(	1	33.0	45.0	66.0	62.0	59.0	52.0	57.0	58.0	78.5	68.5	50.0	62.0	62.6	56.0	61.4
North (	1-1/2	26.5	43.0	64.5	59.0	56.0	50.0	56.0	56.5	76.0	66.5	43.0	58.5	60.7	50.8	58.7
(	2	27.0	43.5	63.0	56.0	53.5	49.0	56.0	55.5	75.5	66.0	40.5	57.0	59.3	48.8	57.1
South (	3	33.5	39.5	62.0	56.0	52.0	46.5	55.5	55.0	72.5	60.5	41.0	50.0	57.5	45.5	55.1
(	4	26.5	40.0	59.0	51.0	48.5	43.5	54.0	53.0	68.5	54.0	36.0	47.5	53.9	41.8	51.4
North (	5	32.0	36.0	55.5	50.5	46.0	40.0	52.0	51.5	64.0	47.5	36.5	41.0	50.9	38.8	48.4
South (	6	27.0	38.0	54.0	45.5	44.0	39.0	51.5	49.5	60.0	43.5	31.5	40.0	48.3	35.8	45.7
South (	Temp. drop in 6 hrs.	---	---	15.0	24.0	22.5	25.0	15.5	11.5	25.0	40.5	34.0	46.5	22.4	40.3	25.9
	6 1/4	---	---	51.5	44.5	44.0	39.0	50.5	48.0	56.0	42.5	38.0	44.0	47.0	41.0	45.8
South (	Temp. change during 3-hr. "soaking period"	---	---	-2.5	-1.0	.0	.0	-1.0	-1.5	-4.0	-1.0	+6.5	+4.0	-1.5	5.3	.0
	7	30.5	35.5	50.0	44.5	42.5	37.0	48.5	47.5	53.5	38.5	34.5	37.5	45.2	36.0	43.3
North (	8	27.5	35.5	48.0	42.0	41.0	36.0	48.0	45.5	52.0	38.0	31.0	37.5	43.8	34.3	41.8
Total temp. drop	7:00 a.m.	---	---	21.0	27.5	25.5	28.0	19.0	15.5	33.0	46.0	34.5	49.0	26.9	41.8	29.8
	5/10 4/	---	---	43.5	41.5	41.5	37.0	46.0	42.5	45.5	37.5	39.0	43.5	41.9	41.3	41.7

1/ Position similar to that where 2nd curtain was placed in Room 3 (see tables 15 and 16).

2/ Position near the location where temperatures are ordinarily obtained by man in charge of precooling operations, not directly under air blast.

3/ Temperatures after 3-hour "soaking period."

4/ Ducts closed at 9:00 p.m., May 9. This reading obtained the next morning.

Table 15. Fruit temperatures obtained near center of Bruce boxes located in the top (4th) layer of precooling room (No. 3) with two curtains. Winter Garden, May 9-10, 1939.

Direction of air blast	Length of precooling period hrs.	air		Fruit										Average			
		Inlet	Outlet	South end		1st Curtain		2nd curtain		North end		Outer		North end	Inner	Outer	Inner and outer
				Center	Side	Center	Side	Center	Side	Center	Side	South end	North end				
South	0			69.0	68.0	70.5	72.0	64.5	71.0	84.0	84.0	71.0	79.5	72.8	75.3	73.2	
	1/2			66.0	62.5	67.0	66.5	53.5	60.0	64.5	72.5	64.5	53.5	64.0	59.0	62.0	
	1			65.0	60.0	65.0	64.0	49.0	57.0	58.0	67.0	64.0	47.0	60.6	58.5	60.1	
North	1-1/2			63.0	54.5	59.5	55.5	50.5	54.0	59.5	65.0	57.5	49.0	57.8	53.0	56.8	
	2			60.5	52.0	55.0	51.5	50.5	53.0	61.5	63.5	55.0	50.5	55.9	52.8	55.2	
South	3			58.0	50.5	54.0	50.0	46.5	50.5	55.0	57.0	56.0	43.0	52.6	49.5	51.9	
	4			53.5	45.0	47.0	43.5	45.0	47.5	54.0	52.5	49.5	42.5	48.5	46.0	48.0	
North	5			51.0	42.5	45.0	41.0	40.0	44.5	46.5	46.5	50.5	37.0	44.6	43.8	44.0	
	6			46.0	39.0	42.0	39.0	40.0	42.5	45.5	43.5	43.0	37.0	42.2	40.0	41.7	
South	Temp. drop in 6 hours			23.0	29.0	28.5	33.0	24.5	28.5	38.5	40.5	28.0	42.5	30.7	30.3	30.6	
	6 2/3			45.0	39.0	41.5	39.0	39.5	42.5	47.5	42.5	46.5	40.5	42.0	43.5	42.3	
South	Temp. change during 3-hr. "soaking period"			-1.0	.0	-.5	.0	-.5	.0	+2.0	-1.0	+3.5	+3.5	-.1	+3.5	+0.6	
	7			45.0	39.0	41.5	38.5	36.5	41.5	41.5	39.0	45.5	32.5	40.5	39.0	40.2	
North	8			42.5	37.0	39.0	36.5	37.5	40.0	42.5	39.0	41.5	34.0	39.2	37.8	38.9	
	Total temp. drop			26.5	31.0	31.5	35.5	27.0	31.0	41.5	45.0	29.5	45.0	33.6	37.5	34.3	
	7:00 a.m.			41.5	37.0	38.5	38.0	37.0	40.5	43.5	37.5	43.0	41.0	39.2	42.0	39.7	
	5/10 2/3																

1/ Position near location where temperatures are ordinarily obtained by man in charge of precooling operations, not directly under air blast.

2/ Temperatures after 3-hr. "soaking" period.

3/ Ducts closed at 9:00 p.m., May 9. This reading obtained the next morning at 7:00 a.m.

4/ At position corresponding to quarterlength in Room 5.



Table 16. Fruit temperatures obtained near center of Bruce boxes located in the bottom layer of precooling room (No. 3) with 2 curtains, Winter Garden, May 9 - 10, 1939.

Direction of air blast	Length of precooling period hrs.	Air		Fruit										Average		Inner and outer °F
		Inlet °F	Outlet °F	South end		1st curtain		2nd 4/ curtain		North end		Outer 1/		Inner °F	Outer °F	
				Center °F	Side °F	Center °F	Side °F	Center °F	Side °F	Center °F	Side °F	South end °F	North end °F			
South (	0	---	---	69.0	64.5	77.0	68.0	70.5	68.0	82.5	83.5	71.0	79.5	72.8	75.3	73.2
(	1/2	31.0	51.5	66.5	62.5	62.5	66.0	68.0	67.0	77.0	58.5	64.5	53.5	66.0	59.0	64.6
(	1	31.0	50.0	65.0	61.0	60.0	64.5	66.0	64.0	74.5	49.5	64.0	47.0	63.0	55.5	61.5
North (	1-1/2	29.0	46.5	63.5	58.5	56.0	61.0	59.0	54.0	71.0	51.0	57.5	49.0	59.2	53.3	58.0
(	2	28.5	46.5	61.0	56.0	51.5	59.0	55.0	50.0	69.0	52.5	55.0	50.5	56.7	52.8	55.9
South (	3	31.0	44.0	59.0	54.5	49.0	56.0	54.0	50.5	65.5	44.5	56.0	43.0	54.1	49.5	53.2
(	4	30.0	41.0	55.0	50.5	45.0	52.5	48.0	43.5	60.0	43.5	49.5	42.5	49.7	46.0	48.9
North (	5	29.5	39.5	51.5	48.0	42.0	49.0	47.0	43.0	56.0	36.5	50.5	37.0	46.6	43.8	46.0
South (	6	30.5	37.5	50.0	44.5	40.5	47.5	43.0	40.0	53.0	36.5	43.0	37.0	44.4	40.0	43.5
South (	Temp. drop in 6 hrs.	---	---	19.0	20.0	36.5	20.5	27.5	28.0	29.5	47.0	28.0	42.5	28.5	35.3	29.8
	6 2/3	---	---	48.0	43.0	39.5	46.0	43.0	41.5	50.0	38.0	46.5	40.5	43.6	43.5	43.5
South (	Temp. change during 3-hr. "Soaking period"	---	---	-2.0	-1.5	-1.0	-1.5	.0	+1.5	-3.0	+1.5	+3.5	+3.5	-.7	+3.5	+1
	7	28.0	38.0	47.5	43.0	40.5	45.5	42.5	41.0	48.5	32.5	45.5	32.5	42.6	39.0	41.8
North (	8	30.5	36.0	45.5	41.0	38.0	43.0	40.0	38.0	47.0	33.0	41.5	34.0	40.6	37.8	40.0
	Total temp. drop			23.5	23.5	39.0	25.0	30.5	30.0	35.5	50.5	29.5	45.5	32.2	37.5	33.2
	7:00 a.m. 5/10 1/2			43.0	40.0	38.0	42.5	40.5	40.0	42.5	37.5	43.0	41.0	40.5	42.0	40.4

1/ Position near location where temperatures are ordinarily obtained by man in charge of precooling operations, not directly under air blast.

2/ Temperatures after 3-hour "soaking period".

3/ Ducts closed at 9:00 p.m., May 9. This reading obtained the next morning.

4/ At position corresponding to quarterlength in Room 5.



Precooling Test No. 2

Winter Garden, Fla., May 16-17.

Room 11 - Equipped with one curtain about midway of room.

Oranges wrapped and packed in standard boxes.

This room was of approximately the same size as those described in precooling test No. 1. The same method of designating the various parts of the room in the tables is also used for this test.

The thermometers were located in the bottom, 2nd and top (4th) layers of the load in the south end of the room. Since the direction of the air blast was reversed at regular intervals it was believed that approximately the same temperature conditions would prevail in both ends of the room. The bulb of the thermometer was inserted in an orange in the second row of fruit from the outside of the box.

Precooling log. The fruit was placed in this room on May 16.

A record of the direction of air movement follows:

Started 11:30 am - Inlet on north end.  
12:30 pm - Air reversed - Inlet, south end.  
1:30 pm - " " " north "  
2:30 pm - " " " south "  
3:30 pm - " " " north "  
4:30 pm - " " " south "  
5:45 pm - " " " north "  
6:10 pm - " " " south "  
6:30 pm - Fans off.  
8:30 pm - Fans started. Inlet south end.  
9:30 pm - Air reversed. " north "  
10:30 pm - Fans off.

Air velocity:

1:30 pm - 1200 ft./min.

5:30 pm - 3200 ft./min.

Several rooms on until about 4:00 pm; at 5:30 pm only room 11 being precooled.

Temperatures during precooling: Fruit temperatures in various parts of the precooling room are given in Tables 17, 18 and 19, which are arranged in the same way as those for Test No. 1. The "temperature drop in 7 hours" and the "total drop" show where the fruit was rapidly cooled and where the least temperature drop was obtained.

The low temperatures obtained in the top layer at the south end and at the curtain show that with the low temperatures of the delivery air there was danger of freezing the fruit at these locations, and that possibly the delivery air temperature should not be allowed to drop below 30° for very long.

Table 17. Temperatures obtained in second row of wrapped oranges packed in standard boxes loaded in top (4th) layer of precooling room (No. 11) with one curtain.  
Winter Garden, May 16-17, 1939

Air										Fruit				
Direc- tion of Air Blast	Length of Pre- cooling Period	Inlet Outlet		Inner						Outer 1/		Average		Inner and Outer
				South End Center Side	Quarterlength Center Side	At curtain Center Side	South End	At Curtain	Inner	Outer				
		Hours	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	
South	0	--	--	83.5	82.0	84.5	84.0	83.0	81.5	78.0	80.0	83.1	79.0	82.1
	(1/2	--	53.5	81.0	80.0	82.5	79.0	77.0	63.0	72.0	60.5	77.1	66.8	74.4
	(1	--	50.0	79.5	78.0	81.5	75.5	74.0	57.5	69.0	56.0	74.3	62.5	71.4
North	(1 1/2	31.5	--	62.0	74.0	69.0	74.5	63.0	51.0	54.5	39.5	65.6	47.0	61.0
	(2	31.5	--	57.0	72.0	66.0	72.5	59.5	49.0	50.0	38.5	62.6	44.3	58.0
South	(2 1/2	--	45.5	58.5	72.0	69.5	71.0	53.0	49.5	49.5	42.5	62.2	46.0	58.2
	(3	--	45.5	58.5	71.0	70.0	69.5	56.0	48.5	49.5	42.0	62.2	45.8	58.1
North	(4	31.5	--	50.0	68.0	63.5	64.0	51.0	42.5	42.0	37.0	56.6	39.5	52.3
South	(5	--	40.0	49.0	65.5	64.5	62.0	48.5	41.0	42.0	37.5	55.1	39.8	51.3
North	(6	25.5	--	40.0	60.5	54.0	58.0	41.5	34.5	34.5	29.0	48.1	31.8	44.0
South														
North	(7	24.5	--	35.5	57.0	51.5	55.0	37.5	31.0	31.5	27.0	44.6	29.3	40.8
Temperature drop in 7 hours		--	--	48.0	25.0	33.0	29.0	45.5	50.5	46.5	53.0	38.5	49.8	41.2
North (7 1/2)		--	--	34.0	52.5	51.0	53.0	34.5	31.5	33.5	34.0	42.7	33.8	40.5
Temperature change during 2-hr. soaking period"				-1.5	-4.5	- .5	-2.0	-3.0	+5	+2.0	+7.0	-1.8	+4.5	-.2
South (8	30.5	--	--	34.5	50.5	51.0	47.5	33.0	28.0	32.5	28.5	40.9	30.5	38.3
(9	23.5	--	--	30.0	46.5	42.5	46.5	30.0	26.0	28.5	25.0	36.9	26.8	34.4
Total temperature--	--	--	--	53.5	35.5	42.0	37.5	53.0	55.5	49.5	55.0	46.2	52.8	47.7
drop														
7:00 am 5/17 3/	--	--	--	34.5	42.0	45.5	42.5	31.5	31.5	36.5	38.0	37.9	37.3	37.7

1/ Outer row of fruit in box near position where temperature readings are obtained by man in charge of precooling operations.

2/ Temperatures after "soaking" period of 2 hours (6:30 to 8:30 pm).

3/ Ducts closed at 10:30 pm, May 16. These temperatures obtained next morning.



Table 18. Fruit temperatures obtained in second row of wrapped oranges packed in standard boxes loaded in second layer of precooling room (No. 11) with one curtain. Winter Garden, May 16-17, 1939.

Air		Fruit																
Direc- tion of Air	Length of Pre- cooling Period	Inlet		Outlet		Inner								Outer 1/		Average		
		Inlet	°F	°F	°F	Quarterlength				At Curtain				South End	°F	°F	°F	°F
						Center	Side	Center	Side	Center	Side	Center	Side					
	Hours	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F
	0	--	--	84.5	82.5	84.0	80.5	81.0	83.0	78.0	80.0	82.6	79.0	80.5	82.6	79.0	80.5	80.5
South	(1/2)	--	53.5	83.0	81.0	81.0	68.0	71.0	73.0	72.0	60.5	76.2	66.8	73.8	76.2	66.8	73.8	73.8
	(1)	--	50.0	82.5	79.0	80.0	66.5	64.5	68.0	69.0	56.0	73.4	62.5	70.7	73.4	62.5	70.7	70.7
North	(1 1/2)	31.5	--	77.5	74.0	74.5	64.0	51.5	60.5	54.5	39.0	67.0	47.0	62.0	67.0	47.0	62.0	62.0
	(2)	31.5	--	76.0	71.5	73.0	63.5	48.0	57.5	50.0	38.5	64.9	44.3	59.7	64.9	44.3	59.7	59.7
South	(2 1/2)	--	45.5	75.0	71.0	73.0	59.0	47.5	56.5	49.5	42.5	63.7	46.0	59.3	63.7	46.0	59.3	59.3
	(3)	--	45.5	74.5	71.0	72.5	56.5	46.5	55.0	49.5	42.0	62.7	45.8	58.5	62.7	45.8	58.5	58.5
North	(4)	31.5	--	68.0	67.5	68.0	57.5	42.5	50.0	42.0	37.0	58.9	39.5	55.3	58.9	39.5	55.3	55.3
South	(5)	--	40.0	67.0	66.0	68.0	50.5	40.5	48.0	42.0	37.5	56.6	39.8	52.4	56.6	39.8	52.4	52.4
North	(6)	25.5	--	61.0	60.0	62.5	50.5	35.5	41.5	34.5	29.0	51.8	31.8	46.8	51.8	31.8	46.8	46.8
South	(7)	24.5	--	58.0	56.5	59.0	45.0	32.0	38.0	31.5	27.0	48.1	29.8	43.2	48.1	29.8	43.2	43.2
Temperature drop in 7 hours				26.5	26.0	25.0	35.5	49.0	45.0	46.5	53.0	34.5	49.8	39.6	34.5	49.8	39.6	39.6
North	(7 2/3)	--	--	55.0	53.0	56.0	45.5	31.0	35.5	33.5	34.0	45.7	33.8	42.7	45.7	33.8	42.7	42.7
Temperature change during 2-hr. "soaking period"				-3.0	-3.5	-3.0	+5	-1.0	-2.5	+2.0	+7.0	-2.0	+4.5	- .4	-2.0	+4.5	- .4	- .4
South	(8)	30.5	--	54.0	50.5	54.5	36.5	30.0	32.5	32.5	28.5	43.0	30.5	39.9	43.0	30.5	39.9	39.9
	(9)	23.5	--	48.5	46.0	50.0	38.5	27.5	30.5	28.5	25.0	40.2	26.8	36.8	40.2	26.8	36.8	36.8
Total temperature drop				36.0	36.5	34.0	42.0	53.5	52.5	49.5	55.0	42.4	52.8	44.9	42.4	52.8	44.9	44.9
7:00 AM 5/17 3/				45.5	43.5	48.0	39.5	30.5	31.5	36.5	38.0	39.7	37.7	40.3	39.7	37.7	40.3	40.3

1/ Outer row of fruit in box near position where temperature readings are obtained by man in charge of precooling operations.

2/ Temperatures after "soaking" period of 2 hours (6:30 to 8:30pm)

3/ Ducts closed at 10:30 pm, May 16. These temperatures obtained next morning.

Table 19. Fruit temperatures obtained in second row of wrapped oranges packed in standard boxes loaded in the bottom layer of precooling room (No. 11) with one curtain.  
Winter Garden, May 16-17, 1939

Air				Fruit									
Direc- tion of Air Blast	Length of Pre- cooling Period	Inlet		Inner						Outer 1/		Average	
		Inlet	Outlet	South End		Quarterlength		At Curtain		South At End	Inner	Outer	Inner and Outer
				Center	Side	Center	Side	Center	Side				
	Hours	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F
South	0	--	--	85.0	83.0	84.0	80.0	83.0	83.0	78.0	80.0	83.0	79.0
	(1/2	--	53.5	83.0	82.0	81.0	66.0	72.5	73.5	72.0	60.5	76.3	65.3
	(1	--	50.0	82.0	81.5	79.5	58.5	68.5	67.5	69.0	56.0	72.9	62.5
North	(1-1/2	31.5	--	77.0	77.0	75.5	60.0	55.0	61.0	54.5	39.5	67.6	47.0
	(2	31.5	--	76.5	75.5	74.0	59.0	52.5	58.0	50.0	38.5	65.9	44.3
South	(2 1/2	--	45.5	76.0	75.5	73.0	56.0	54.5	56.0	49.5	42.5	65.2	46.0
	(3	--	45.5	75.0	75.5	73.0	54.5	53.5	54.5	49.5	42.0	64.3	45.8
North	(4	31.5	--	71.5	71.5	69.0	55.0	48.0	51.0	42.0	37.0	61.0	39.5
South	(5	--	40.0	69.5	70.5	67.5	49.0	47.0	47.5	42.0	37.5	58.5	39.8
North	(6	25.5	--	64.0	66.5	63.0	47.0	38.0	47.5	34.5	29.0	54.5	31.8
South	(7	24.5	--	60.5	64.0	59.5	42.0	35.5	38.5	31.5	27.0	50.0	29.3
Temperature drop in 7 hours				24.5	19.0	24.5	38.0	47.5	44.5	46.5	53.0	33.0	49.8
North	(7 2/	--	--	56.5	60.0	56.0	42.5	36.0	37.5	33.5	34.0	48.1	33.8
Temperature change during 2-hr. soaking period				-4.0	-4.0	-3.5	.0	+ .5	-1.0	+2.0	+7.0	-2.0	+4.5
													-0.4
South	(8	30.5	--	55.0	58.0	54.0	34.0	35.0	33.5	32.5	28.5	44.9	30.5
	(9	23.5	--	51.0	54.5	50.0	35.5	30.5	31.5	28.5	25.0	42.2	26.8
Total drop				34.0	28.5	34.0	44.5	52.5	51.5	49.5	55.0	41.0	52.3
7:00 am, 5/17 3/		--	--	45.5	46.5	48.5	39.5	34.0	32.0	36.5	38.0	41.0	37.3
													40.0

1/ Outer row of fruit in box near position where temperature readings are obtained by man in charge of precooling operations.

2/ Temperatures after "soaking" period of 2 hours (6:30 to 8:30 pm).

3/ Ducts closed at 10:30 pm, May 16. These temperatures obtained next morning.

Precooling Test No. 3

Haines City, Fla., May 25, 1939

FGE 18495 - Oranges packed in Bruce boxes loaded 4 layers high, 7 rows wide and 14 stacks long (2 stacks next bulk-head 4 layers high) total 400 boxes. Precooled by platform precooling unit.

Temperatures were obtained with electric resistance thermometers in the top, second and bottom layers of the load. The bulb of the thermometer was inserted in an orange near the middle of the box, which is the slowest to cool.

The refrigeration for the precooling unit was obtained from brine circulated from stationary refrigeration machinery located in the engine room of the packing house. The precooling unit consisted of a cold diffuser and a powerful fan for circulating the air over the coils and through the carload of fruit. The cooled air was discharged into the car through an opening near the top doorway. A canvas baffle laid over the top of the load, extending to the quarterlength, forced the cooled air toward the ends of the car. The return air was drawn through an opening near the bottom doorway. Precooling started at 10:45 a.m. and stopped at 3:00 p.m., a total of 4-1/4 hours.

Temperatures during precooling: The outside temperature during precooling ranged from 84° to 92° F. The fruit temperatures in various parts of the load are given in table 20. This table is so arranged that a comparison can be made of individual and average temperatures of the top, second and bottom layers with those obtained at the top layer doorway position, which is accessible to the operator and is used in obtaining his records.



The "temperature drop in 4-1/4 hours" as given in this table, shows where the maximum and minimum temperature drop was obtained.

These data indicate that 4-1/4 hours of precooling are not sufficient to thoroughly cool the load and that a lower delivery air temperature would have been desirable.

The figures in the last column of the table show that in precooling by this method the temperature of the fruit at the top doorway cannot be taken as an indication of the average temperature of the load except at the start of precooling.

Table 20. Fruit temperatures obtained near center of Bruce boxes loaded in a refrigerator car and precooled with a platform precooling unit at Haines City, Fla., May 25, 1939.

Length of precool- ing period	Air		Bunker		Quarter- length		Doorway		Aver- age	Top door- way <u>1/</u>
	Inlet	Return	Center <sup>2/</sup>	Side <sup>2/</sup>	Center	Side	Center	Side		
hrs.	°F	°F	°F	°F	°F	°F	°F	°F	°F	°F
Bottom layer										
0	---	---	79.0	79.5	80.0	81.5	81.0	81.0	80.3	82.0
1/2	84.5	74.0	75.0	69.0	77.0	80.0	77.0	78.0	76.0	67.5
1	51.0	71.5	71.5	64.0	75.5	79.0	73.0	73.5	72.9	63.5
1-1/2	49.0	69.0	67.5	61.0	74.5	78.0	70.0	70.0	70.2	61.0
2-1/4	47.5	65.0	63.0	56.5	72.5	76.0	65.5	65.0	66.4	58.5
3	46.0	63.5	59.0	54.0	71.0	74.5	63.0	62.0	63.9	56.5
4-1/4	45.0	60.0	54.5	50.5	69.5	72.0	59.0	58.0	60.6	53.0
Temp. drop in 4-1/4 hours			24.5	29.0	10.5	9.5	22.0	23.0	19.7	29.0
Second layer from floor rack										
0	---	---	78.5	79.5	82.5	81.5	82.0	---	80.8	82.0
1/2	84.5	74.0	77.5	69.5	77.5	79.0	79.5	---	76.7	67.5
1	51.0	71.5	76.5	64.0	75.0	77.0	77.0	---	73.9	63.5
1-1/2	49.0	69.0	75.5	60.5	73.0	75.5	74.5	---	71.8	61.0
2-1/4	47.5	65.0	73.5	56.0	71.0	73.0	71.5	---	69.0	58.5
3	46.0	63.5	72.5	53.5	70.5	71.0	68.5	---	67.2	56.5
4-1/4	45.0	60.0	69.5	50.0	68.0	68.0	65.0	---	64.1	53.0
Temp. drop in 4-1/4 hours			9.0	29.5	14.5	13.5	17.0	---	16.7	29.0
Top (4th) layer										
0	---	---	78.5	76.0	85.0	84.5	82.5	79.5	81.0	82.0
1/2	84.5	74.0	76.0	73.5	82.5	78.5	78.0	74.5	77.2	67.5
1	51.0	71.5	73.5	71.0	79.5	74.0	67.5	71.0	72.7	63.5
1-1/2	49.0	69.0	71.5	68.5	77.0	70.0	63.5	68.0	69.7	61.0
2-1/4	47.5	65.0	67.5	65.0	72.5	64.0	59.0	63.5	65.2	58.5
3	46.0	63.5	65.5	62.0	70.0	60.5	56.0	61.0	62.5	56.5
4-1/4	45.0	60.0	61.5	57.5	66.5	55.0	52.0	57.5	58.3	53.0
Temp. drop in 4-1/4 hours			17.0	18.5	18.5	29.5	30.5	22.0	22.5	29.0

1/Fruit temperature at top layer doorway position, accessible to operator of precooling unit.

2/Center - centerline of car; side - row next to sidewall of car.

General Comments on Precooling

The following general comments deal with facts brought out by a comparison of the results obtained in the three precooling tests.

The effect of reversing the direction of the air blast through the precooling rooms can be seen by reference to tables 13 to 19 inclusive. It was frequently very marked, as for example in the fruit nearest the air duct in Test 1, Room 5, top layer (see table 13). The direction of the air blast at the beginning of precooling was from north to south, but 1 hour and 15 minutes later it was reversed, and was then from south to north. Before the reversal the fruit cooled most rapidly in the north end but soon after the change was made the drop was accelerated in the south end and was greater there than in the north end, or at any other locations in the room except in the center of the mass of fruit, at the curtain. In this same room the direction of air movement was reversed again, this time from north to south, about 2 hours after precooling began. Soon after this change was made fruit temperatures at the north end showed as pronounced a drop as had the south-end temperatures after the first reversal of the air blast. Instances like these two can be noted at various places in all of the tables for Test 1.

As would be expected, a reversal of the direction of the air blast, made early in the test, had a more marked effect on fruit temperatures than did one made late in the test.

The average drop per hour in fruit temperature in tests 1, 2 and 3 is shown in table 21. It will be noted that the rates of cooling for different positions in test 1 shown in this table (both rooms) are slower than those for corresponding positions in the room used in test 2.



This difference is probably due to the fact that the fruit in test 2 averaged over 12 degrees warmer at the start than that used in test 1. It is well known that under the same refrigeration, warm fruit cools faster than fruit that is not so warm, at least during the first few hours after cooling begins.

In tests 2 and 3 the starting temperature of the fruit was about the same (test 2, average 82.9°, test 3, average 80.7°). It will be noted, however, that, on the average, and at comparable positions, the fruit in the refrigerated room cooled 0.7 to 1.8 degrees faster per hour than the fruit in the refrigerator car cooled by a platform precooling unit outside the car.

Table 21. Average drop per hour in fruit temperature in three precooling tests, Florida, May 9-25, 1939

Test no.	Place of precooling	Kind of precooling	Length of precooling period	Layer	Inside fruit	Outside fruit	Inside and outside fruit	Starting temp. of fruit
			hrs.		°F	°F	°F	°F
1	Room 5	Refrig. room	6	Top	5.0	6.7	5.3	70.7
	" 5	"	8	"	4.1	5.2	4.4	70.7
	" 5	"	6	Bot.	3.7	6.7	4.3	70.7
	" 5	"	8	"	3.3	5.2	3.7	70.7
	" 3	"	6	Top	5.1	5.0	5.1	72.8
	" 3	"	8	"	4.2	4.7	4.3	72.8
	" 3	"	6	Bot.	4.7	5.9	4.9	72.8
	" 3	"	8	"	4.0	4.7	4.1	72.8
2	" 11	"	7	Top	5.5	7.1	5.9	83.1
	" 11	"	9	"	5.1	5.9	5.3	83.1
	" 11	"	7	2nd	4.9	7.1	5.7	82.6
	" 11	"	9	"	4.7	5.9	5.0	82.6
	" 11	"	7	Bot.	4.7	7.1	5.3	83.0
	" 11	"	9	"	4.5	5.9	4.9	83.0
3	Car	Cold diffuser	4.25	Top	---	---	5.2	81.0
				2nd	---	---	3.9	80.8
				Bot.	---	---	4.6	80.3

The changes in fruit temperature during a 3-hour "soaking period" in tests 1 and 2, rooms 5, 3 and 11, are shown in table 22. Averages for inner fruit, outer fruit, and the two combined are given in the last three columns of the table. These figures show that the average change for each lot considered as a whole was very small. If only the inner fruit is considered, the average change was greatest in room 5 (test 2) which contained the warmest fruit. The most striking fact brought out by this table is that in all three rooms (as indicated by temperatures recorded at two positions) the average temperature of the outside fruit showed a marked rise, ranging from  $3.5^{\circ}$  F in room 3 to  $5.2^{\circ}$  in room 5. The results of these tests indicate that the value of a "soaking period" is found in the opportunity it affords to prevent fruit that is freely exposed to the air blast from reaching a dangerously low temperature and at the same time affording opportunity for some further cooling of the warmer fruit through the natural equalization of temperature in the mass.



Table 22. Change in fruit temperature during "soaking period," in precooling tests Nos. 1 and 2, Florida, May 9-17, 1939.

Test no.	Room no.	Length of pre-cooling period hrs.	Inner fruit										Outer fruit		Average		Layer
			South end		At 1st curtain		Quarterlength		North end		South end	North end	Inner	Outer	Inner and outer		
Center	Side	Center	Side	Center	Side	Center	Side	Center	Side	of F	of F	of F	of F	of F			
1	5	6	.0	+0.5	+0.5	--	-2.0	+1.5	.0	.0	+6.5	+4.0	.0	+5.2	+1.2	Top	
	5	6	-2.5	-1.0	.0	.0	-1.0	-1.5	-4.0	-1.0	+6.5	+4.0	-1.5	+5.2	.0	Bottom	
	3	6	-1.0	.0	-0.5	-0	At 2nd curtain	0	+2.0	-1.0	+3.5	+3.5	-0.1	+3.5	+0.6	Top	
	3	6	-2.0	-1.5	-1.0	-1.5	.0	+1.5	-3.0	+1.5	+3.5	+3.5	-0.7	+3.5	+0.1	Bottom	
2	11	7	-1.5	-4.5	-3.0	+0.5	Quarterlength	-2.0	--	--	+2.0	At curtain	-1.8	+4.5	-0.2	Top	
	11	7	-3.0	-3.5	-1.0	-2.5	-0.5	+0.5	--	--	+2.0	+7.0	-2.0	+4.5	-0.4	Second	
	11	7	-4.0	-4.0	+0.5	-1.0	-3.5	.0	--	--	+2.0	+7.0	-2.0	+4.5	-0.4	Bottom	